(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 June 2001 (14.06.2001)

PCT

(10) International Publication Number
WO 01/42273 A2

(51) International Patent Classification[7]: C07J

(21) International Application Number: PCT/US00/33526

(22) International Filing Date:
11 December 2000 (11.12.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/169,959 9 December 1999 (09.12.1999) US

(71) Applicant *(for all designated States except US)*: MAGAININ PHARMACEUTICALS, INC. [US/US]; 5110 Campus Drive, Plymouth Meeting, PA 19462 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: LEVITT, Roy, C. [US/US]; 5110 Campus Drive, Plymouth Meeting, PA 19462 (US). NICOLAIDES, Nicholas [US/US]; 5110 Campus Drive, Plymouth Meeting, PA 19462 (US). KINNEY, Bill [US/US]; 5110 Campus Drive, Plymouth Meeting, PA 19462 (US). JONES, Steve [US/US]; 5110 Campus Drive, Plymouth Meeting, PA 19462 (US).

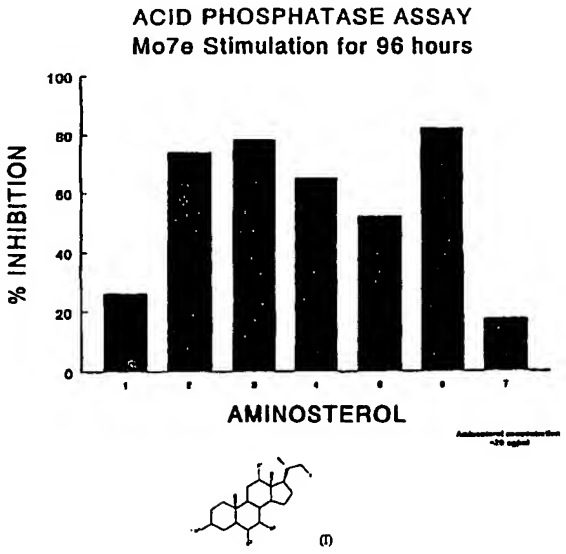
(74) Agent: TUSCAN, Michael, S.; Morgan, Lewis & Bockius LLP, 1800 M Street, N.W., Washington, DC 20036-5869 (US).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: ASTHMA ASSOCIATED FACTORS AS TARGETS FOR TREATING ATOPIC ALLERGIES INCLUDING ASTHMA AND RELATED DISORDERS



(I)

(57) Abstract: This invention relates to methods for treating asthma or allergy in a mammal by administering a 3-aminosteroid compound to a mammal in need thereof. The 3-aminosteroid compound being capable of down regulating the IL-9 pathway and alleviating asthmatic responses to allergen. Exemplary 3-aminosteroid compounds used in the methods of the invention include compounds having the chemical formula (I), wherein X, R^1, R^2, R^3, and R^4 groups are as defined herein. The invention also relates to certain novel compound of formula (I). Moreover, the invention also provides methods for identifying an immunomodulatory 3-aminosteroid compound.

WO 01/42273 A2

Published:
— *Without international search report and to be republished upon receipt of that report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

ASTHMA ASSOCIATED FACTORS AS TARGETS FOR TREATING ATOPIC ALLERGIES INCLUDING ASTHMA AND RELATED DISORDERS

CROSS REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application 60/169,959 filed December 9, 1999 which is herein incorporated by reference in its entirety. This application is related to U.S. Application 09/325,571 filed June 9, 1999 which is a continuation of U.S. Application 08/874,503 filed August 23, 1996, now abandoned, which claims the benefit of U.S. Provisional Application 60/002,765 filed August 24, 1995 all of which are herein incorporated by reference in their entirety. This application is also related to U.S. Application 09/198,486 filed November 24, 1998; U.S. Application 08/769,689 filed December 18, 1996 now U.S. Patent 5,856,535; and U.S. Application 08/478,763 filed June 7, 1995 now U.S. Patent 5,721,226 all of which are herein incorporated by reference in their entirety.

FIELD OF THE INVENTION

This invention relates to methods for treating atopic allergies and related disorders, such as asthma, in a mammal. More particularly, the invention relates to methods for regulating IL-9 activity in a mammal by administering a 3-aminosteroid compound that down regulates the IL-9 pathway and asthmatic responses to allergen. The invention also relates to certain novel 3-aminosteroid compounds. In addition, the invention also provides methods for identifying immunomodulatory 3-aminosteroid compounds.

BACKGROUND OF THE INVENTION

Inflammation is a complex process in which the body's defense system combats foreign entities. While the battle against foreign entities may be necessary for the body's survival, some defense systems respond to foreign entities, even innocuous ones, as dangerous and thereby damage surrounding tissue in the ensuing conflict.

Atopic allergy or atopy, is an ecogenetic disorder, where genetic background dictates the response to environmental stimuli, such as pollen, food, dander and insect venoms. The

disorder is generally characterized by an increased ability of lymphocytes to produce IgE antibodies in response to ubiquitous antigens. Activation of the immune system by these antigens leads to allergic inflammation and may occur after ingestion, penetration through the skin or after inhalation. When this immune activation occurs and is accompanied by pulmonary inflammation and bronchial hyperresponsiveness, this disorder is broadly characterized as asthma. Many cell types are involved in this inflammatory reaction and they include T cells and antigen-presenting cells, B cells that produce IgE and basophils and eosinophils that bind IgE. These inflammatory cells accumulate at the site of allergic inflammation and the toxic products they release contribute to tissue destruction related to these disorders.

While asthma is generally defined as an inflammatory disorder of the airways, clinical symptoms arise from intermittent air flow obstruction. It is a chronic, disabling disorder that appears to be increasing in prevalence and severity (Gergen *et al.*, (1992) Am. Rev. Respir. Dis. 146, 823-824). It is estimated that 30-40% of the population suffer with atopic allergy and 15% of children and 5% of adults in the population suffer from asthma (Gergen *et al.*, (1992) Am. Rev. Respir. Dis. 146, 823-824). Thus, an enormous burden is placed on our health-care resources.

Interestingly, while most individuals experience similar environmental exposures, only certain individuals develop atopic allergy and asthma. This hypersensitivity to environmental allergens known as atopy, is often indicated by elevated serum IgE levels or abnormally intense skin test response to allergens in atopic individuals as compared to non-atopics (Marsh *et al.*, (1982) New Eng. J. Med. 305, 1551-1559). Strong evidence for a close relationship between atopic allergy and asthma is derived from the fact that most asthmatics have clinical and serologic evidence of atopy (Clifford *et al.*, (1987) Arch. Dis. Childhood 62, 66-73; Gergen, (1991) Arch. Intern. Med. 151, 487-492; Burrows *et al.*, (1992) J. Allergy Clin. Immunol. 90, 376-385; Johannson *et al.*, (1972) Prog. Clin. Immunol. 1, 1-25; Sears *et al.*, (1991) New Engl. J. Med. 325, 1067-1071; Halonen *et al.*, (1992) Am. Rev. Respir. Dis. 146, 666-670). In particular, younger asthmatics have a high incidence of atopy (Marsh *et al.*, (1982) New Eng. J. Med. 305, 1551-1559). In addition, immunologic factors associated with an increase in total serum IgE levels are very closely related to impaired pulmonary function (Burrows *et al.*, (1989) New Eng. J. Med. 320, 271-277).

Both the diagnosis and treatment of these disorders are problematic (Gergen *et al.*, (1992) Am. Rev. Respir. Dis. 146, 823-824). The assessment of inflamed lung tissue is often difficult and frequently the source of the inflammation cannot be determined. Without knowledge of the source of the airway inflammation and protection from the inciting foreign environmental agent or agents, the inflammatory process cannot be interrupted. It is now generally accepted that failure to control pulmonary inflammation leads to significant loss of lung function over time.

Current treatments suffer from their own set of disadvantages. The main therapeutic agents, beta receptor agonists, reduce the symptoms thereby transiently improving pulmonary function, but do not affect the underlying inflammation so that lung tissue remains in jeopardy. In addition, constant use of beta receptor agonists results in desensitization which reduces their efficacy and safety (Molinoff *et al.*, (1995) Goodman and Gilman's The Pharmacologic Basis of Therapeutics, MacMillan Publishing). The agents that can diminish the underlying inflammation, the anti-inflammatory steroids, have their own list of disadvantages that range from immunosuppression to bone loss (Molinoff *et al.*, (1995) Goodman and Gilman's The Pharmacologic Basis of Therapeutics, MacMillan Publishing).

Because of the problems associated with conventional therapies, alternative treatment strategies have been evaluated. Glycophorin A (Chu *et al.*, (1992) Cell. Immunol. 145, 223-239), cyclosporin (Alexander *et al.*, (1992) Lancet 339, 324-328; Morely, (1992) J. Autoimmun. 5 Suppl A, 265-269) and a nonapeptide fragment of interleukin 2 (IL-2) (Zavyalov *et al.*, (1992) Immunol. Lett. 31, 285-288) all inhibit potentially critical immune functions associated with homeostasis. What is needed in the art is a treatment for asthma that addresses the underlying pathogenesis. Moreover, these therapies should address the episodic nature of the disorder and the close association with allergy and intervene at a point downstream from critical immune functions.

In the related patent applications mentioned above, applicants have demonstrated that interleukin 9 (IL-9), its receptor and activities effected by IL-9 are the appropriate targets for therapeutic intervention in atopic allergy, asthma and related disorders.

Mediator release from mast cells by allergen has long been considered a critical initiating event in allergy. IL-9 was originally identified as a mast cell growth factor and it has been demonstrated that IL-9 up-regulates the expression of mast cell proteases including MCP-1, MCP-2, MCP-4 (Eklund *et al.*, (1993) J. Immunol. 151, 4266-4273) and granzyme B

(Louahed *et al.*, (1995) J. Immunol. 154, 5061-5070). Thus, IL-9 appears to serve a role in the proliferation and differentiation of mast cells. Moreover, IL-9 up-regulates the expression of the alpha chain of the high affinity IgE receptor (Dugas *et al.*, (1993) Eur. J. Immunol. 23, 1687-1692). Elevated IgE levels are considered to be a hallmark of atopic allergy and a risk factor for asthma. Furthermore, both *in vitro* and *in vivo* studies have shown IL-9 to potentiate the release of IgE from primed B cells (Petit-Frere *et al.*, (1993) Immunology 79, 146-151).

There is substantial support for the role of IL-9 gene in asthma. First, linkage homology between humans and mice suggests that the same gene is responsible for producing biologic variability in response to antigen in both species. Second, differences in expression of the murine IL-9 candidate gene are associated with biologic variability in bronchial responsiveness. In particular, reduced expression of IL-9 is associated with a lower baseline bronchial response in B6 mice (Nicolaides *et al.*, (1997) Proc. Natl. Acad. Sci. USA 94, 13175-13180). Third, recent evidence for linkage disequilibrium in data from humans suggests IL-9 may be associated with atopy and bronchial hyperresponsiveness consistent with a role for this gene in both species (Doull *et al.*, (1996) Am. J. Respir. Crit. Care Med. 153, 1280-1284). Moreover, a genetic alteration in the human gene appears to be associated with loss of cytokine function and lower IgE levels. Fourth, the pleiotropic functions of this cytokine and its receptor in the allergic immune response strongly support a role for the IL-9 pathway in the complex pathogenesis of asthma. Fifth, in humans, biologic variability in the IL-9 receptor also appears to be associated with atopic allergy and asthma. Finally, despite the inherited loss of IL-9 receptor function, these individuals appear to be otherwise healthy. Thus, nature has demonstrated in atopic individuals that the therapeutic down-regulation of IL-9 and IL-9 receptor genes or genes activated by IL-9 and its receptor is likely to be safe.

Airway hyperresponsiveness is found in virtually all asthmatics and in some strains of inbred mice (DBA2) (Levitt *et al.*, (1995) Clin. Exp. Allergy 25, 61-63). Airway hyperresponsiveness is a risk factor for the development of asthma in humans and is used in animal models of asthma as a physiologic measure to assess the efficacy of treatment for asthma. This data along with human (Postma *et al.*, (1995) New Engl. J. Med. 333, 894-900) and murine genetic mapping results (U.S. Patent 5,908,839) suggests a critical role for the murine IL-9 gene product in the airway response of the mouse. In particular, the bronchial hyperresponsive DBA2 mice differ from the C57BL6 hyporesponsive mice (Nicolaides *et al.*, (1997) Proc. Natl. Acad. Sci. USA 94, 13175-13180) in their expression of steady state levels

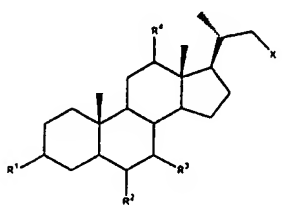
of IL-9 (U.S. Patent 5,908,839). Furthermore, pretreatment with blocking antibodies to IL-9 and its receptor can optionally provide complete protection from antigen induced airway hyperresponsiveness and inflammation in mice demonstrating a critical regulatory role for IL-9 in these immune responses. This data demonstrates that although different molecular changes produce biologic variability in airway responsiveness in humans and mice, these changes arise in the same gene(s) (IL-9 and its receptor) that regulate this pathway. Taken together, these observations confirm the critical role of IL-9 and its receptor in airway hyperresponsiveness, asthma and atopic allergy. Moreover, this data demonstrates that agents of the invention, which block IL-9 action(s), protect against an antigen induced response such as those detailed above.

While the role of the IL-9 gene, its receptor and their functions in atopic allergy, asthma and related disorders has been elucidated, a specific need in the art exists for elucidation of the role of genes which are regulated by IL-9 in the etiology of these disorders. Furthermore, most significantly, based on this knowledge, there is a need for the identification of agents that are capable of regulating the activity of these genes, their gene products and their subsequent biological activities for treating these disorders.

SUMMARY OF THE INVENTION

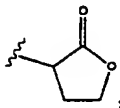
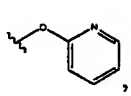
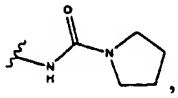
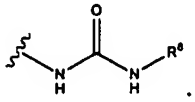
This invention relates to methods of treating atopic allergy and asthma in a mammal comprising administering an effective amount of a 3-aminosteroid compound. In a preferred embodiment, the 3-aminosteroid compound down regulates the IL-9 pathway and asthmatic responses to allergen.

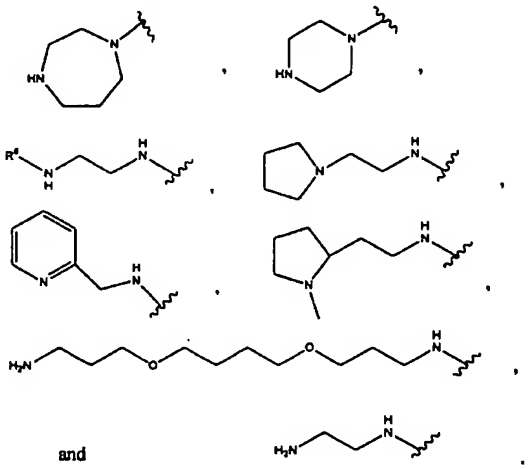
Exemplary 3-aminosteroid compounds used in the methods of the invention include compounds having the chemical formula (I) below:

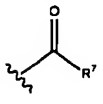


(I)

In Formula (I), the X group is selected from the group consisting of —CH_2—$PO(OR^5)_2$, —NH—SO_2—R^5, —NH—CO—OR^5, —CH_2—CO—NH_2, —CH_2—CO—NH—R^8, —CH_2—CO_2—R^5,




, and  . The R^1 group is selected from the group consisting of R^6—NH_2—,



The R^2, R^3, and R^4 groups are each independently selected from the group consisting of H, —OH, —OAc, and  . The R^5 group is a C_{1-12} alkyl, and the R^6, R^7 and R^8 are each independently selected from the group consisting of H, C_{1-6} alkyl, and phenyl. The invention also relates to certain novel 3-aminosteriod compounds having formula (I).

This invention includes a method for identifying a immunomodulatory 3-aminosteroid compound comprising culturing peripheral blood lymphocytes in the presence of a 3-aminosteroid compound and a mitogen to form cell aggregates; and determining the number of cell aggregates wherein an immunomodulatory 3-aminosteroid compound reduces the number of cell aggregates when compared to peripheral blood lymphocytes cultured in the absence of the 3-aminosteroid compound.

In an another embodiment, this invention also encompasses a method for identifying a immunomodulatory 3-aminosteroid compound comprising culturing peripheral blood lymphocytes in the presence of a 3-aminosteroid compound and a mitogen; and determining the level of IL-9 mRNA wherein an immunomodulatory 3-aminosteroid compound reduces the level of IL-9 mRNA when compared to peripheral blood lymphocytes cultured in the absence of the 3-aminosteroid compound. In a preferred embodiment the peripheral blood lymphocytes are cultured in the presence of mitogen for about twelve hours.

In yet another embodiment, the invention includes a method for identifying a immunomodulatory 3-aminosteroid compound comprising culturing peripheral blood lymphocytes isolated from antigen-stimulated mammal in the presence of a 3-aminosteroid compound and an antigen to form cell aggregates; and determining the number of cell aggregates wherein an immunomodulatory 3-aminosteroid compound reduces the number of cell aggregates when compared to peripheral blood lymphocytes cultured in the absence of the 3-aminosteroid compound. In a preferred embodiment, the peripheral blood lymphocytes are cultured in the presence of antigen for three days and the antigen-stimulated mammal is a mouse.

In a further embodiment, the invention includes a method for identifying a immunomodulatory 3-aminosteroid compound comprising culturing cells which proliferate in response to IL-9 in the presence of IL-9 and a 3-aminosteroid compound; and measuring the level of cell proliferation wherein an immunomodulatory 3-aminosteroid compound reduces the level of cell proliferation induced by IL-9 when compared to cells cultured in the absence of the 3-aminosteroid compound. In a preferred embodiment, the cells which proliferate in response to IL-9 are Mo7e cells.

The accompanying figures, which are incorporated in and constitute a part of this specification, illustrate several embodiments of the invention and, together with the description, serve to explain the principle of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1: Inhibition by various 3-aminosteroids of IL-9 mediated M07e proliferation.

Figure 2: Aminosterols derived from the dogfish shark.

Figure 3: Analogues of 3-aminosteroids derived from the dogfish shark.

Figure 4: 3-aminosteroids prepared from acylated or sulfonylated 22-amines.

Figure 5: 3-aminosteroid analogues prepared via the 22-aldehyde.

Figure 6: 3-aminosteroids prepared via the Mitsunobu reaction.

Figure 7: 24-Amide 3-aminosteroid analogue.

Figure 8: Novel 3-aminosteroids with ester-isosteres.

Figure 9: Novel 3-aminosteroid esters with modified polyamines.

Figure 10: Novel acylated 3-aminosteroid esters.

Figure 11: Effect of 3-aminosteroids on human lymphocyte aggregation.

Figure 12: Effect of 3-aminosteroids on human lymphocyte proliferation.

Figure 13: Effect of 3-aminosteroid on mitogen-induced induction of IL-9

Figure 14: Inhibition of bronchial hyperresponsiveness in mice by 3-aminosteroids.

Figure 15: Inhibition of bronchial hyperresponsiveness in DBA2J mice by dexamethasone and Compound-A.

Figure 16: Inhibition of eosinophilia in mice by dexamethasone and Compound-A.

Figure 17: Inhibition of IgG1 production in sensitized DBA2J mice by dexamethasone and Compound-A.

Figure 18: Inhibition of IgE production in sensitized DBA2J mice by dexamethasone and Compound-A.

Figure 19: Inhibition of bronchial hyperresponsiveness in BALBc mice by Compound-A.

Figure 20: Effect of dexamethasone or Compound-B on plasma corticosterone in Sprague-Dawley rats.

Figure 21: Effect of dexamethasone or Compound-B on spleen weight in Sprague-Dawley rats.

Figure 22: Effect of Compounds A, B or Dexamethasone on spleen weight in mice.

DETAILED DESCRIPTION OF THE INVENTION

Applicant has resolved the needs in the art by elucidating an IL-9 pathway and compositions that affect that pathway that may be used in the diagnosis, prevention or treatment of atopic allergy including asthma and related disorders. Asthma encompasses inflammatory disorders of the airways with reversible airflow obstruction. Atopic allergy refers to atopy and related disorders including asthma, bronchial hyperresponsiveness, rhinitis, urticaria, allergic inflammatory disorders of the bowel and various forms of eczema. Atopy is

a hypersensitivity to environmental allergens expressed as the elevation of serum IgE or abnormal skin test responses to allergens as compared to controls.

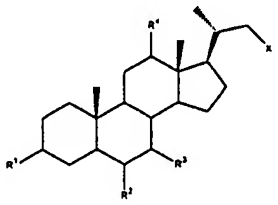
Further evidence defining the role of IL-9 in the pathogenesis of atopic allergy, bronchial hyperresponsiveness, asthma and related disorders derives directly from the applicants observation that IL-9 is critical to a number of antigen induced responses in mice. When the functions of IL-9 are down-regulated by antibody or 3-aminosteroid, the animals can be completely protected from the antigen induced responses. These responses include: bronchial hyperresponsiveness, eosinophilia and elevated cell counts in bronchial lavage, histologic changes in the lung associated with inflammation and elevated serum IgE. The treatment of such responses, which are critical to the pathogenesis of atopic allergy and which characterize the allergic inflammation associated with asthma, by the down-regulation of the functions of IL-9, are within the scope of this invention.

Applicants have found that 3-aminosteroid compounds are also useful in the inhibition of signal transduction due to IL-9 stimulation. 3-aminosteroid compounds which are useful in this invention are described in U.S. Patent 5,637,691 and related U.S. Patents 5,733,899 and 5,721,226 as well as in 5,840,740 and its related U.S. Patents 5,795,885; 5,763,430; 5,840,936; 5,874,597; 05,792,635; 5,994,336 and 5,847,172 which are specifically incorporated herein by reference. In a preferred embodiment of the invention, 3-aminosteroid compounds A, B, D, J and L and derived analogues are useful for the treatment of atopic allergy and asthma. Any compounds derived from compounds A, B, D, J and L including alterations to the core sterol molecule, which are useful for the treatment of atopic allergy and asthma is encompassed in the invention.

Applicant also provides for a method to screen for the compounds that down-regulate the expression of IL-9 or the functions controlled by IL-9. One may determine whether the functions expressed by IL-9 are down-regulated using techniques standard in the art (Miyazawa *et al.*, (1992) Blood 80, 1685-1692; Yin *et al.*, (1994) J. Biol. Chem. 269, 26614-26617; Renauld *et al.*, (1992) Proc. Natl. Acad. Sci. USA 89, 5690-5694; Chang *et al.*, (1994) Blood 83, 3199-3205). In one embodiment, serum IgE may be measured using techniques well known in the art (Meyers *et al.*, (1994) Genomics 23, 464-470) to assess the efficacy of a compound in down-regulating the functions of IL-9 *in vivo*. In another *in vivo* assay, bronchial hyperresponsiveness and eosinophilia in bronchoalveolar lavage may be measured using techniques well known in the art (Meyers *et al.*, (1994) Genomics 23, 464-470).

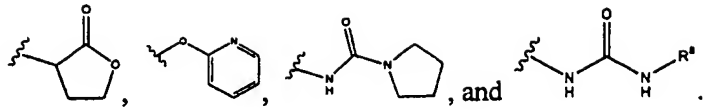
In yet another embodiment, the functions of IL-9 may be assessed *in vitro*. Specific assays may be based on regulation, in part, of the proliferation of T lymphocytes, IgE synthesis and release from mast cells by IL-9 (Renauld *et al.*, (1990) J. Immunol. 144, 4235-4241; Kelleher *et al.*, (1991) Blood 77, 1436-1441; Houssiau *et al.*, (1995) J. Immunol. 154, 2624-2630; Miyazawa *et al.*, (1992) Blood 80, 1685-1692; Yin *et al.*, (1994) J. Biol. Chem. 269, 26614-26617; Renauld *et al.*, (1992) Proc. Natl. Acad. Sci. USA 89, 5690-5694; Chang *et al.*, (1994) Blood 83, 3199-3205). Another assay involves the ability of human IL-9 to specifically induce the rapid and transient tyrosine phosphorylation of multiple proteins in M07e cells (Miyazawa *et al.*, (1992) Blood 80, 1685-1692). Because this response is dependent on the expression and activation of the IL-9 receptor, it represents a simple method or assay for the characterization of potentially valuable compounds. The tyrosine phosphorylation of Stat3 transcriptional factor appears to be specifically related to the actions of IL-9 (Yin *et al.*, (1994) J. Biol. Chem. 269, 26614-26617) and this response represents a simple method for the characterization of compounds within the invention. Still another method to characterize the function of IL-9 and similar molecules involves the well known murine TS1 clone and the D10 clone available from ATCC which is used to assess human IL-9 function with a cellular proliferation assay (Renauld *et al.*, (1992) Proc. Natl. Acad. Sci. USA 89, 5690-5694). Still another method to monitor the effect of pharmacologic compounds is by measuring IL-9 expression in mitogen-stimulated primary lymphocytes, where the suppression of IL-9 prevents the activation of the lymphocytes.

Exemplary 3-aminosteroid compounds for use in the invention have chemical formula (I), shown below:

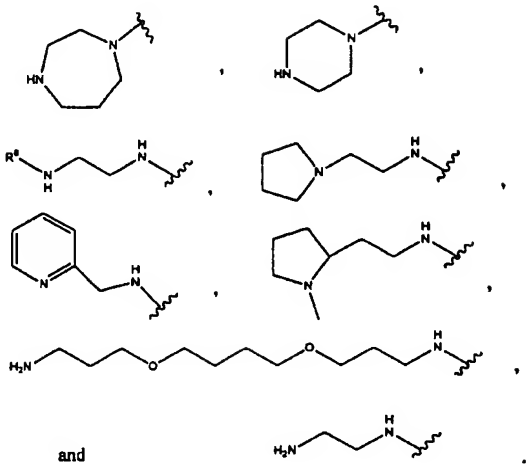


(I)

In Formula (I), the X group is selected from the group consisting of —CH_2—$PO(OR^5)_2$, —NH—SO_2—R^5, —NH—CO—OR^5, —CH_2—CO—NH_2, —CH_2—CO—NH—R^8, —CH_2—CO_2—R^5,

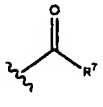


. The R^1 group is selected from the group consisting of R^6—NH_2—,

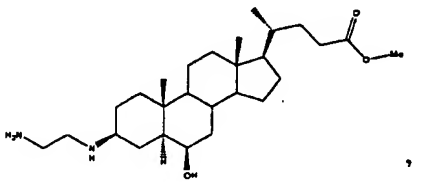


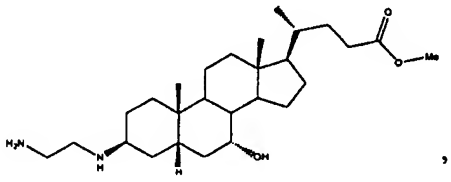
and

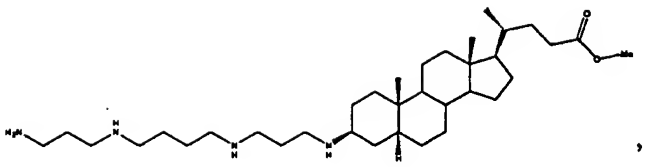
.

The R^2, R^3, and R^4 groups are each independently selected from the group consisting of H, —OH, —OAc, and  . The R^5 group is a C_{1-12} alkyl, and the R^6, R^7 and R^8 are each independently selected from the group consisting of H, C_{1-6} alkyl, and phenyl.

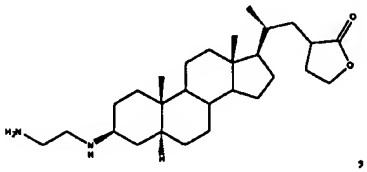
Exemplary 3-aminosteroid compounds used in the methods of the invention, include the following:



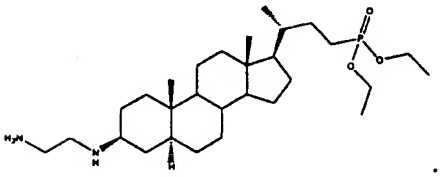




,

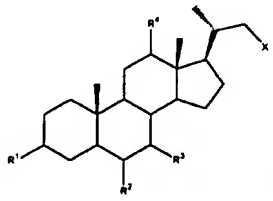


, and



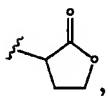
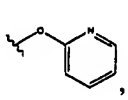
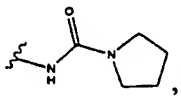
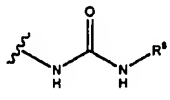
.

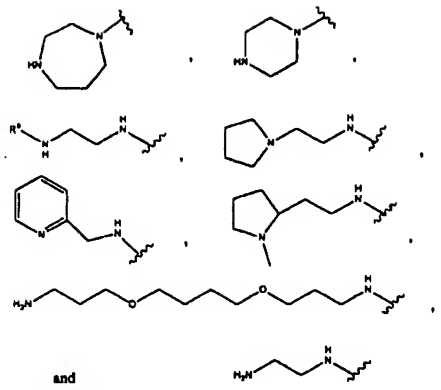
In addition, the invention also relates to certain novel 3-aminosteroid compounds of formula (I). Such compounds are also useful in the practice of the methods of the invention. These include compounds of formula (II), below:

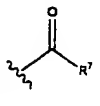


(II)

The X group is selected from the group consisting of —CH_2—$PO(OR^5)_2$, —NH—SO_2—R^5, —NH—CO—OR^5, —CH_2—CO—NH_2, —CH_2—CO—NH—R^8, —CH_2—CO_2—R^5,

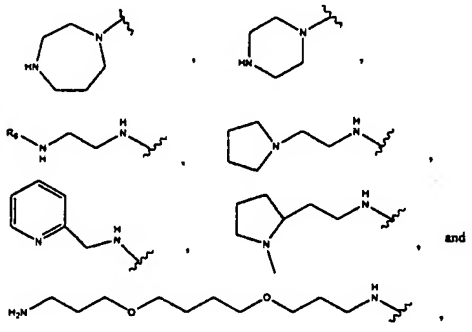

,

,

, and

. The R^1 is selected from the group consisting of R^6—NH_2—,

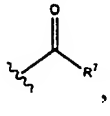


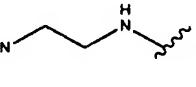
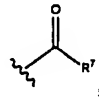
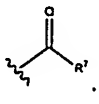
The R^2, R^3, and R^4 groups are each independently selected from the group consisting of H, —OH, —OAc, and  . The R^5 group is a C_{1-12} alkyl, and the R^6, R^7 and R^8 groups are each independently selected from the group consisting of H, C_{1-6} alkyl, and phenyl.

An embodiment of the invention relates to compounds of formula (II), where the X is selected from the group consisting of —CH_2—$PO(OR^5)_2$, —NH—SO_2—R^5, —NH—CO—OR^5, —CH_2—CO—NH_2, —CH_2—CO—NH—R^8,

Another embodiment of the invention relates to compounds of formula (II), where the X group is —CH_2—CO_2—R^5, and the R^1 group is selected from the group consisting of: R^6—NH_2—,



In this embodiment, the R^2, R^3, and R^4 groups are independently selected from the group consisting of H, —OH, —OAc, and  , the R^5 group is a C_{1-12} alkyl, and the R^6 and R^7 groups are each independently selected from the group consisting of H, C_{1-6} alkyl, and phenyl.

In yet another emobidmen, the invention also relates to compounds of formula (II), where the X group is —CH_2—CO_2—R^5, the R^1 group is  , and the R^2, R^3, and R^4 groups are each independently selected from the group consisting of H, —OH, —OAc, and  , with the proviso that at least one of R^2, R^3, and R^4 is  . In this embodiment, the R^5 group is a C_{1-12} alkyl, and R^7 is selected from the group consisting of H, C_{1-6} alkyl, and phenyl.

It is to be understood in the above discussion that the alkyl groups may be straight or branched. The alkyl and phenyl groups may be optionally substituted with halogen, alkoxy, or a water-solubilizing group. A "water-solubilizing group" is a substituent that increases the solubility of a compound in aqueous solution. Exemplary water-solubilizing groups include, but are not limited to, quaternary amine, sulfate, sulfonate, carboxylate, phosphate, phosphonate, polyether, polyhydroxyl, boronate, and amide groups such as --$CONH_2$ and $CONHCH_3$. The water solubilizing groups may also include sulfo, sulfonamido, carbonamido, sulfamoyl, carbamoyl, hydroxyl, and salts thereof.

In addition, the invention includes pharmaceutical compositions comprising the compounds of the invention or their salts together with a pharmaceutically acceptable carrier. Pharmaceutically acceptable carriers can be sterile liquids, such as water and oils, including those of petroleum, animal, vegetable or synthetic origin, such as peanut oil, soybean oil, mineral oil, sesame oil and the like. Water is a preferred carrier when the pharmaceutical composition is administered intravenously. Saline solutions and aqueous dextrose and glycerol solutions can also be employed as liquid carriers, particularly for injectable solutions. Suitable pharmaceutical carriers are described in Remington's Pharmaceutical Sciences, Mack Publishing Company, 1995, specifically incorporated herein by reference.

In another embodiment, a pharmaceutical compound or composition of the invention is provided as a packaged formulation. The packaged formulation may include a pharmaceutical

composition of the invention in a container or inhalation device and printed instructions for administration of the composition to a subject or patient exhibiting the symptoms of asthma or allergy. The packaged formulation may also contain instructions for the administration of the composition to a subject or patient in combination with another compound or composition having a known activity against asthma or allergy. In another format, the packaged formulation may contain the pharmaceutical composition with general written material indicating or suggesting the use of the composition and any other compounds or formulations contained therein for treating a patient diagnosed with or exhibiting the symptoms of asthma or allergy.

The compounds used in the method of treatment of this invention may be administered systemically or topically, depending on such considerations as the condition to be treated, need for site-specific treatment, quantity of drug to be administered and similar considerations.

Topical administration may be used. Any common topical formulation such as a solution, suspension, gel, ointment or salve and the like may be employed. Preparation of such topical formulations as are well described in the art of pharmaceutical formulations as exemplified, for example, by Remington's Pharmaceutical Sciences. For topical application, these compounds could also be administered as a powder or spray, particularly in aerosol form. The active ingredient may be administered in pharmaceutical compositions adapted for systemic administration. As is known, if a drug is to be administered systemically, it may be confected as a powder, pill, tablets or the like or as a syrup or elixir for oral administration. For intravenous, intra-peritoneal or intra-lesional administration, the compound will be prepared as a solution or suspension capable of being administered by injection. In certain cases, it may be useful to formulate these compounds in suppository form or as an extended release formulation for deposit under the skin or intramuscular injection. In a preferred embodiment, the compounds of this invention may be administered by inhalation. For inhalation therapy the compound may be in a solution useful for administration by metered dose inhalers or in a form suitable for a dry powder inhaler.

An effective amount is that amount which will down-regulate IL-9 activity. A given effective amount will vary from condition to condition and in certain instances may vary with the severity of the condition being treated and the patient's susceptibility to treatment. Accordingly, a given effective amount will be best determined at the time and place through routine experimentation. However, it is anticipated that in the treatment of atopic allergy,

asthma and asthma-related disorders in accordance with the present invention, a formulation containing between 0.001 and 5% by weight, preferably about 0.01 to 1%, will usually constitute a therapeutically effective amount. When administered systemically, an amount between 0.01 and 100 mg per kg body weight per day, but preferably about 0.1 to 10 mg/kg, will effect a therapeutic result in most instances.

Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed. It is intended that the specifications and examples be considered exemplary only with a true scope of the invention being indicated by the claims. Having provided this background information, applicant now describes preferred aspects of the invention.

EXAMPLE 1

RNA isolations, RT-PCR, cloning and sequencing of RT-PCR products

Total cellular RNA was extracted after 24 hours from cultured PBMC, murine spleen cells and M07e cells using RNA PCR corekit (Perkin-Elmer, Foster City CA) according to manufacturer's instructions. One microgram of RNA from each source was denatured for five minutes at 65°C and then reverse transcribed into cDNA using a 20 µl reaction mixture containing 50 units of MLV Reverse Transcriptase, one unit per µl RNAse inhibitor, 2.5 mM oligo d(T)16 primer, 1 mM each dATP, dCTP, dGTP, dTTP, 50 mM KCl, 10 mM Tris-HCl, pH 7.0, 25 mM $MgCl_2$. The reaction mixture was pipetted into thermocycler tubes, placed in a PCR thermal cycler and subjected to one cycle (fifteen minutes at 42°C, five minutes at 99°C and five minutes at 4°C). A mock reverse transcription reaction was used as a negative control.

This mixture was then added to a second tube containing 2 mM $MgCl_2$, 50 mM KCl, 10 mM Tris-HCl, pH 7.0, 65.5 µl deionized water, 2.5 units Amplitaq DNA polymerase and 1 µl (20 µM) each of oligonucleotides representing human cDNA IL-9 exon 1 (forward) and exon 5 (reverse), for a final volume of 100 µl. The reaction mixture was subjected to the following PCR conditions: two minutes at 98°C, then 30 cycles at thirty seconds at 94°C, forty seconds at 55°C, forty seconds at 72°C. Finally, the reaction mixture was cycled one time for fifteen minutes at 72°C for extension.

PCR products representing human IL-9 or IL-9R cDNA were subjected to gel electrophoresis through 1.5% agarose gels and visualized using ethidium bromide staining.

Products of a mock reverse transcriptase reaction, in which water was substituted for RNA was used as negative control amplification in all experiments.

EXAMPLE 2

IL-9 biological assay in M07e cells

The M07e line is a human megakaryoblastic cell line, cultured in RPMI-1640, 20% fetal bovine serum and 10 ng/ml IL-3 (R&D Systems). The cell line responds to cytokines including IL-9. The cells were fed and split at 2×10^5 cells per milliliter every 72 hours.

The cells were centrifuged for ten minutes at 2000 rpm and resuspended in RPMI-1640 with 0.5% bovine serum albumin and insulin-transferrin-selenium (ITS) cofactors (Gibco-BRL). Cells were counted using a hemocytometer and diluted to a concentration of 1×10^5 cells/ml and plated in a 96-well microtiter plate. Each well contained 2×10^4 cells per well. The cells were stimulated with 50 ng/ml Stem Cell Factor (SCF) alone, 50 ng/ml SCF plus 50 ng/ml IL-3 (R&D Systems) or 50 ng/ml SCF plus 50 ng/ml IL-9. A control was included which contained cells and basal media only. Serial dilutions of test compounds were added to each test condition in triplicate. Cultures were incubated for 72-96 hours at 37°C in 5% CO_2.

Cell proliferation was assayed using the Abacus® Cell Proliferation Kit (Clontech) which determines the amount of intracellular acid phosphatase present as an indication of cell number. The substrate p-nitrophenyl phosphate (pNPP), was converted by acid phosphatase to p-nitrophenol, which was measured as an indicator of enzyme concentration. pNPP was added to each well and incubated at 37°C for one hour. Sodium hydroxide was then added to stop the enzymatic reaction and the amount of p-nitrophenol was quantified using a Dynatech® 2000 plate reader at 410 nm wavelength. Standard curves that compare cell number with optical absorbance were used to determine the linear range of the assay. Assay results were only used when absorbance measurements were within the linear range of the assay.

Figure 1 illustrates the effect of aminosterols isolated from the shark liver (Figure 2) as set forth in U.S. Patents 5,637,691; 5,733,899; 5,721,226 and 5,840,740 incorporated herein by reference, on the IL-9 dependent growth of M07e cells *in vitro*. Each 3-aminosteroid was incubated with M07e cells at 20 μg/ml of the culture media and inhibition of cellular growth induced by IL-9 was determined by comparison with control conditions (no treatment). There

was no evidence for cytotoxicity with any of the treatments. 3-aminosteroids 3 and 6 (Figure 2) consistently provided the greatest inhibition of growth.

EXAMPLE 3

Identification of immunomodulatory 3-aminosteroids *in vitro*

Immunomodulatory 3-aminosteroids (Figures 3-7 and Table I) were identified *in vitro* based on their ability to inhibit homo- or hetero-typic aggregation and subsequent proliferation of mitogen or antigen stimulated murine or human lymphocytes. Human or mouse lymphocytes were isolated from peripheral blood by Ficoll-Hypaque as described (Stoeckert *et al.*, (1990) Exp. Hematol. 18, 1164-1170). For mitogen stimulation, 1×10^5 cells per well were plated in varying amounts of 3-aminosteroid compounds and assayed for aggregation and proliferation after twelve hours of stimulation by PHA-PMA mitogens. Wells were microscopically counted for aggregates of greater than 100 cells to assess aggregation and proliferation was determined using tritiated thymidine incorporation and analysis on a Packard Top Count as suggested by the manufacture. For antigen stimulation, lymphocytes were isolated from BALBc mice which had been sensitized to Aspergillus fumigatus antigen for three weeks and plated at 1×10^5 cells per well with or without 100 units of Aspergillus fumigatus antigen. Cells were grown for three days and then scored for cellular aggregates and proliferation as described above in the presence or absence of increasing amounts of Compound-B or analogue compounds. Compound-B and Compound-A were able to suppress lymphocyte aggregation (Figure 11) and proliferation (Figure 12) at lower doses (IC_{50} = 2.5 μg/ml & 0.5 μg/ml, respectively) than the highly similar compounds D (IC_{50} = 10 μg/ml) and E (IC_{50} > 10 μg/ml). Moreover, the treatment of mitogen-stimulated lymphocytes with compounds A or B was found to block the expression of IL-9 in these cultures in contrast to the effect of control compound E (Figure 13). Similar results were obtained in assays using antigen mediated response to compounds (not shown). These data demonstrate that both the aggregation and proliferation assays are useful for determining structure-activity relationships for this family of 3-aminosteroids. Table I shows the activity of other 3-aminosteroid compounds in the assays described above. All of the active compounds shown in Table I as well as rational modifications of these compounds as depicted in Figures 8-10 are embodiments of the invention

EXAMPLE 4

Efficacy of immunomodulatory 3-aminosteroids in suppression of asthmatic response

DBA2, C57BL6 or B6D2F1 mice, five to six weeks of age, were obtained from the National Cancer Institute or Jackson Laboratories. Animals were housed in high-efficiency particulate filtered air laminar flow hoods in a virus and antigen free facility and allowed free access to pelleted rodent chow and water for three to seven days prior to experimental manipulation. The animal facilities were maintained at 22°C and the light:dark cycle is automatically controlled (10:14 hour cycle).

Phenotyping and efficacy of pretreatment. Animals either received no pretreatment or were sensitized by nasal aspiration of Aspergillus fumigatus antigen to assess the effect on bronchial hyperresponsiveness, bronchoalveolar lavage and serum IgE. Mice were challenged with Aspergillus or saline intranasally (Monday, Wednesday and Friday for three weeks) and phenotyped twenty-four hours after the last dose. The effect of pretreatment by aminosteroids was used to assess the effect of down-regulating the IL-9 pathway in mice. To determine the bronchoconstrictor response, respiratory system pressure was measured at the trachea and recorded before and during exposure to the drug. Mice were anesthetized and instrumented as previously described. (Kleeberger *et al.*, (1990) Am. J. Physiol. 258, L313-320; Levitt *et al.*, (1995) Clin. Exp. Allergy 25, 61-63; Ewart *et al.*, (1995) J. Appl. Physiol. 79, 560-566). Airway responsiveness was measured to one or more of the following: 5-hydroxytryptamine, acetylcholine, atracurium or a substance-P analogue. A simple and repeatable measure of the change in peak inspiratory pressure following bronchoconstrictor challenge was used which has been termed the Airway Pressure Time Index (APTI). The APTI was assessed by the change in peak respiratory pressure integrated from the time of injection until the peak pressure returns to baseline or plateau. The APTI was comparable to airway resistance, however, the APTI includes an additional component related to the recovery from bronchoconstriction.

Prior to sacrifice, whole blood was collected for serum Ig measurements by needle puncture of the inferior vena cava in anesthetized animals. Samples were centrifuged to separate cells and serum was collected and used to measure total IgG_1, IgG_{2a} and IgE levels. Samples not measured immediately were frozen at -20°C.

Serum Igs were measured using an ELISA antibody-sandwich assay. Microtiter plates were coated, 50 µl per well, with rat anti-murine IgG_1, IgG_{2a} or IgE antibody (Southern

Biotechnology and PharMingen) at a concentration of 2.5 μg/ml in coating buffer of sodium carbonate-sodium bicarbonate with sodium azide. Plates were covered with plastic wrap and incubated at 4°C for sixteen hours. The plates were washed three times with a wash buffer of 0.05% Tween-20 in phosphate-buffered saline, incubating for five minutes for each wash. Blocking of nonspecific binding sites was accomplished by adding 200 μl per well 5% bovine serum albumin in phosphate-buffered saline, covering with plastic wrap and incubating for two hours at 37°C. After washing three times with wash buffer, duplicate 50 μl test samples were added to the wells. Test samples were assayed after being diluted 1:10, 1:50 and 1:100 with 5% bovine serum albumin in wash buffer. In addition to the test samples, a set of Ig standards (PharMingen) at various liner concentrations in 5% bovine serum albumin in wash buffer, were assayed to generate a standard curve. A blank of no sample or standard was used to zero the plate reader (background). After adding samples and standards, the plate was covered with plastic wrap and incubated for two hours at room temperature. After washing three times with wash buffer, 50 μl of secondary antibody rat anti-murine IgG_1, IgG_{2a} or IgE-horseradish peroxidase conjugate was added at a concentration of 250 ng/ml in 5% bovine serum albumin in wash buffer. The plate was covered with plastic wrap and incubated two hours at room temperature. After washing three times with wash buffer, 100 μl of the substrate 0.5 mg/ml o-phenylenediamine in 0.1 M citrate buffer was added to every well. After five to ten minutes the reaction was stopped with 50 μl of 12.5% sulfuric acid and absorbance was measured at 490 nm on a Dynatech® MR5000 plate reader. A standard curve was constructed from the standards with antigen concentration on the x axis (log scale) and absorbance on the y axis (linear scale). The concentration of IgG_1, IgG_{2a} or IgE in the samples was interpolated from the standard curve.

Bronchoalveolar lavage and cellular analysis were preformed as previously described (Kleeberger *et al.*, (1990) Am. J. Physiol. 258, L313-320). Lung histology was carried out after the lungs were removed under anesthesia. Since prior instrumentation may introduce artifact, separate animals were used for these studies. Thus, a small group of animals was treated in parallel exactly the same as the cohort undergoing various pretreatments except these animals were not used for other tests aside from bronchial responsiveness testing. After bronchial responsiveness testing, the lungs were removed and submersed in liquid nitrogen. Cryosectioning and histologic examination was carried out in a manner obvious to those skilled in the art.

Active compounds identified *in vitro* were tested *in vivo* for their ability to suppress airway hyperresponsiveness, lung eosinophilia and serum Ig levels using assays described above. Animals were either unsensitized or sensitized to antigen and dosed with a 3-aminosteroid compound ip at either 1 or 10 mg/kg/day for up to three weeks or 2.5 mg/kg twice a week for four weeks. The ability of these compounds to suppress asthmatic type responses is demonstrated by the data in Figures 14-19. Figure 14 demonstrates that both Compounds-B and-D are effective in suppressing bronchial hyperresponsiveness in D2 naive mice, which are hyperresponsive due to elevated IL-9 levels in their lungs (Nicolaides *et al.*, (1997) Proc. Natl. Acad. Sci. USA 94, 13175-13180) and Compound-B is effective at a lower dose than Compound-D. Figure 15 indicates that the 3-aminosteroid Compound-A is able to block airway hyperresponsiveness in mice sensitized to antigen and that it was more efficacious than the commonly used corticosteroid, dexamethasone (Dex). Figure 16 demonstrates that eosinophils were the particular cell type affected by Compound-A, suggesting that this compound acts on cell types associated with a TH2-allergic response. The inhibition of a TH2-allergic response was also indicated in Figures 17 and 18 where total serum IgG1 and IgE was suppressed but not the TH1 associated immunoglobulin IgG2a. Figure 19 indicates that the 3-aminosteroid Compound-A is able to block airway hyperresponsiveness at a dose as low as 2.5 mg/kg administered twice per week. In summary, these data suggest that 3-aminosteroid compounds and derived analogues have the potential to inhibit asthmatic responses at very low drug concentrations and therefore will be useful for the treatment of asthma with a low incident of side effects in human patients.

EXAMPLE 5

Mechanism of action *in vivo* of immunomodulatory 3-aminosteroids

To determine the mechanism by which 3-aminosteroid compounds function to suppress the asthmatic response to allergen, comparative physiologic assays were carried out utilizing the extensively studied Sprague-Dawley rat model (Scaccianoce *et al.*, (1995) Neuroendocrinology 62, 32-38; Hatzinger *et al.*, (1996) Neuroendocrinology 64, 349-356). Animals were administered 1 mg/kg/day of either the corticosteroid Dexamethasone or Compound-B and analyzed at ten hours for corticosterone and ACTH. As shown in Figure 20, dexamethasone significantly suppressed absolute levels of plasma corticosterone (> 450 fold) eight to ten hours after treatment while Compound-B had no significant effect. Similar results

were found for ACTH levels(> 100 fold) supporting the finding that Compound-B is acting by a different mechanism from dexamethasone. Longer studies, where drug was administered for 28 days, demonstrated that animals tolerated the 3-aminosteroid compounds better than dexamethasone where weight loss and splenic atrophy were observed (Figure 21). Similar data was obtained in mice treated with effective doses of either Compounds A or B (10 mg/kg per day for 22 days) where no splenic atrophy was observed in contrast to dexamethasone treatment (Figure 22). This data combined with the data from Examples 2, 3 and 4 demonstrates that 3-aminosteroid compounds are novel anti-inflammatory and anti-asthma compounds which appear to function by a mechanism unlike that of the dexamethasone class of steroids to suppress the biological response to allergen sensitization.

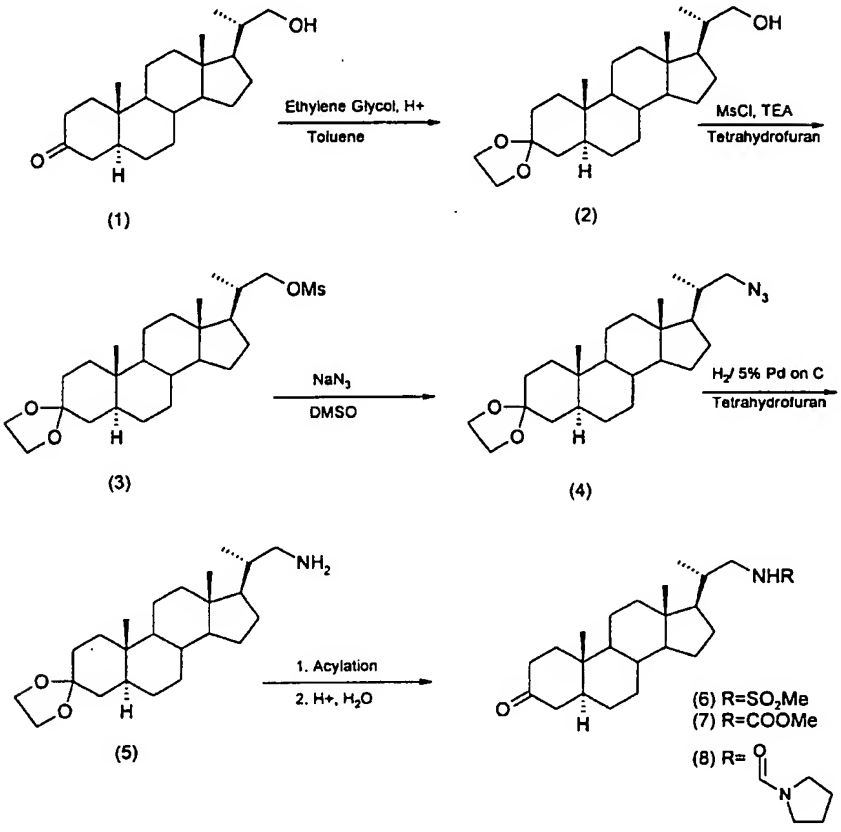
EXAMPLE 6

3-Aminosteroidal esters

The majority of the analogues prepared were accessible from the methods described previously (Jones *et al.*, (1996) Steroids 61, 565-571) using the appropriate polyamine and steroidal ester (Figure 3). In addition, general methods for preparing 3-aminosteroids have also been described previously (Zasloff *et al.*, (1999) U.S. Patent 5,856,535) this reference herein incorporated by reference in its entirety.

A number of 3-aminosteroid analogues were prepared via acylation or sulfonylation of the C22-amine 5, which was prepared as outlined below. The preparation of compounds 1 and 2 has been described previously (Rao *et al.*, (1997) J. Org. Chem. *62*, 4541-4545).

Analogues Prepared via Acylation or Sulfonylation of 22-Amine



Preparation of Compound 3

Compound 2 (5.5 g, 14.6 mmol) was added to THF (100 mL) containing TEA (5 mL), and methanesulfonylchloride (2.0 g, 17.5 mmol) was added dropwise with ice bath cooling. The reaction was judged complete by TLC on silica gel (elution with 60/40 hexane/ethyl acetate) after thirty minutes. The reaction mixture was worked-up by addition of toluene (100 mL) and saturated sodium bicarbonate. The organic layer was washed alternately with sodium bicarbonate and 0.1 M HCl solution. The pooled organic layers were then dried over sodium sulfate to afford crude compound 3 as an off white solid (5.4 g, 11.9 mmol, 81%). The crude mesylate (3) was carried on without further purification.

Preparation of Compound 4

The crude mesylate (5.0 g, 11.0 mmol) was added to DMSO (150 mL). Sodium azide (2.5 g, 38.5 mmol) was added and the reaction was warmed to 60°C until judged complete by

TLC on silica gel (approximately four hours). The reaction was worked-up by the addition of hexane/ethyl acetate 50/50 (~200 mL). The organic layer was repeatedly washed with water to remove the DMSO. The organic layer was dried over sodium sulfate and the solvent removed *in vacuo* to give the crude azide 4 (4.2 g, 10.4 mmol, 94%) which was carried on without further purification.

Preparation of Compound 5

The crude azide 4 (4.2 g, 10.4 mmol) was dissolved in THF (100 mL) in a 250 mL Parr flask. The catalyst (400 mg, 5% Pd on carbon) was added wet under a stream of N_2. The flask was purged with N_2 before introduction of H_2 at 50 psi. The reaction was hydrogenated at room temperature for eight hours. The reaction was worked-up by filtration through Celite® to give the C22-amine 5 (3.9 g, 10.3 mmol, 99%), which was of satisfactory purity.

General Procedure for Acylation of Compound 5

The acylations were carried out via a similar procedure. Compound 5 (~500 mg) was dissolved in THF (10 mL) and TEA (2 mL) was added. The flask was chilled in an ice water bath, and the acylating agent (approximately two equivalents) was added dropwise. The reaction was followed by TLC on silica gel (elution with 20/1 chloroform/methanol). The acylating agents used were methanesulfonyl chloride, methyl chloroformate and pyrolidinecarbonyl chloride. After the reactions were judged to be complete, 20% TFA in water (~20 mL) was added to the flask. If precipitation occurred, acetone was added until the sterol redissolved. The acid solutions were stirred for approximately two hours before being worked-up by extracting into 50/50 toluene/ethyl acetate. The organic layer was washed with water and saturated sodium bicarbonate, dried over sodium sulfate, and evaporated *in vacuo*. This provided crude 3-oxo-22-sulfonamide (compound 6, 437 mg,1.1 mmole, 73%), carbamate (compound 7, 477 mg, 1.2 mmole, 81%) and urea (compound 8, 544 mg, 1.3 mmole, 86%) derivatives of satisfactory purity.

EXAMPLE 7

3-Aminosteroids prepared from acylated or sulfonylated 22-amines

Compounds F, G, H and I (Figure 4) were prepared from acylated or sulfonylated 22-amines.

Reductive Aminations of Compounds 6, 7 and 8

The reductive aminations were accomplished by similar procedures. The sterol (500 mg for, compound 6.2 g for compounds 7 and 8) was dissolved in 2-propanol (25 mL).

Ethylenediamine (1 mL) was added to the flask. The 3-oxo sterol and ethylenediamine were allowed to stir at room temperature for approximately four hours. Sodium cyanoborohydride (250 mg for compound 6 and 100 mg for compounds 7 and 8) was dissolved in 2-propanol (2 mL) and acetic acid (1 mL). The sodium cyanoborohydride solution was added to the reaction flask after evolution of gas had almost ceased (approximately five minutes). In all cases the reaction was complete before the first TLC was taken (less than five minutes). The work-up was the same for all analogues, solution was made basic (pH 10-11) by the addition of carbonate buffer. The aqueous layer was repeatedly extracted with chloroform. The chloroform was removed *in vacuo* and the crude 3-aminosteroid was dissolved in 10% acetonitrile/water, acidified with TFA. The solubility of compound I was very poor. The solutions were passed through a 45 μ Gelman vacu-cap filter. The 3-aminosteroid isomers were separated by reverse phase chromatography on C18 (Dynamax, 300 , 8 μM, 21.6 mm ID, 25 cm/L) using a gradient of acetonitrile in water with 0.1% TFA throughout. The separation of the sulfonamide - (G) and - (F) isomers was accomplished relatively easily, while only the - isomer of the methyl carbamate (H) was isolated cleanly. For the urea analogue the isomers were not effectively separated by chromatography on C18. The urea derivatives were submitted for biological testing as the mixed isomers (I).

Analytical for Compounds F, G, H, and I

Compound-F: ^{1}H NMR (400 MHZ, CD_3OD): 0.74 (s, 3H), 0.89 (s, 3H), 1.04 (d, 3H, J=6.7 Hz), 2.75 (m, 1H), 2.94 (s, 3H), 3.1-3.3 (m, buried in solvent signal); MS (ES) $[M+H]^+$: 454; Anal. Calcd. for $C_{25}H_{47}N_3O_2S$-2TFA-0.8H_2O: C 50.03%, H 7.33%, N 6.04%. Found: C 49.98%, H 7.10%, N 6.00%.

Compound-G: ^{1}H NMR (400 MHZ, CD_3OD): 0.74 (s, 3H), 0.88 (s, 3H), 1.02 (d, 3H, J=6.7 Hz), 2.75 (d of d, 1H, J_1=10 Hz, J_2= 3 Hz), 2.94 (s, 3H), 3.15 (d of d, J_1=10 Hz, J_2=2 Hz), 3.48 (sharp m, 1H); MS (ES) $[M+H]^+$: 454; Anal. Calcd. for $C_{25}H_{47}N_3O_2S$-2TFA-0.8H_2O: C 50.03 %, H 7.33 %, N 6.04 %. Found: C 50.23 %, H 7.38 %, N 6.05%.

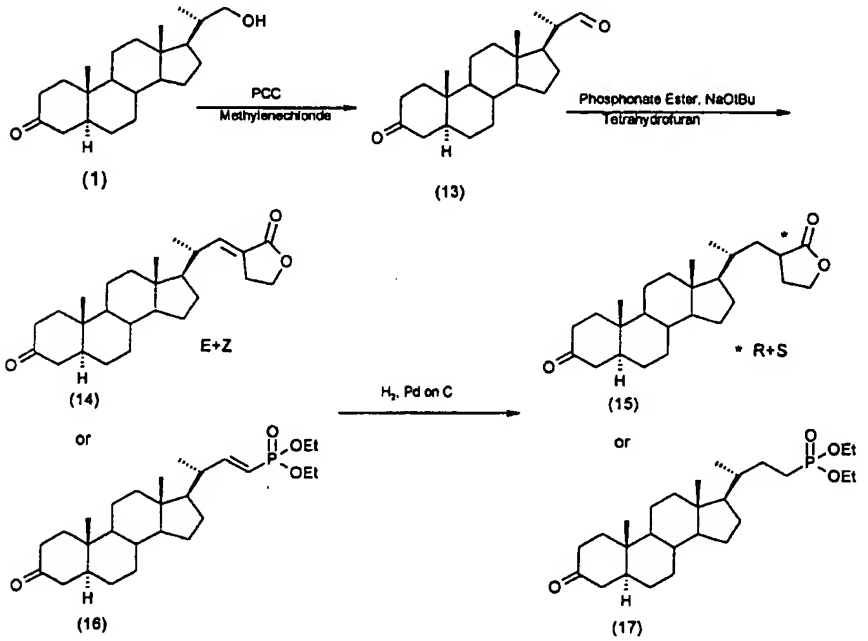
Compound-H: ^{1}H NMR (400 MHZ, CD_3OD): 0.74 (s, 3H), 0.90 (s, 3H), 0.97 (d, 3H, J=6.7 Hz), 2.75 (d of d, 1H, J_1=10 Hz, J_2= 3 Hz), 3.20 (m, 2H), 3.66 (s, 3H); MS (FAB) $[M+H]^+$: 434; Anal. Calcd. for $C_{26}H_{47}N_3O_2$-2TFA-1.5H_2O: C 52.32 %, H 7.61 %, N 6.10 %. Found: C 52.10 %, H 7.31 %, N 5.78%.

Compound-I: ^{1}H NMR (400 MHZ, CD_3OD): 0.69 (s, 3H), 0.84 (s, 3H, 2 signals from the mixed isomers), 0.93 (d, 3H, J=6.7 Hz), 2.75 (m, 1H), 3.10-3.30 (m, buried in solvent peak),

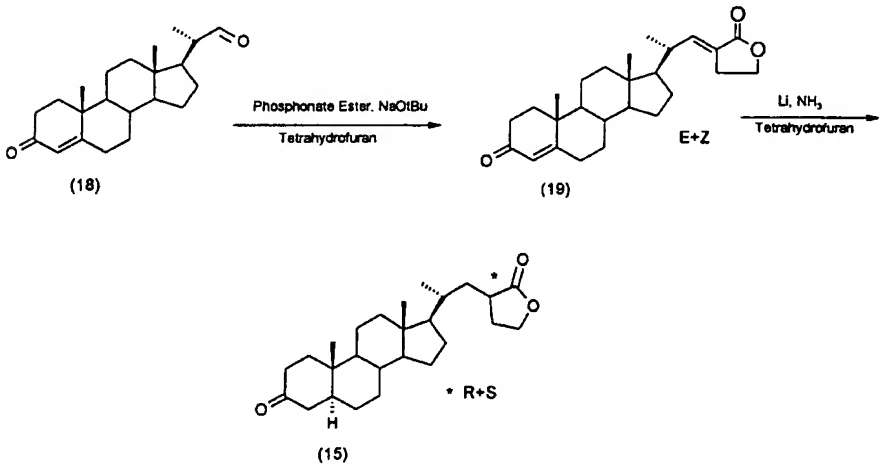
3.45 (sharp m); MS (FAB) $[M+H]^+$: 474; Anal. Calcd. for $C_{29}H_{52}N_4O_1$-2TFA-$2H_2O$: C 53.79 %, H 7.93 %, N 7.60 %. Found: C 53.91 %, H 7.35 %, N 7.74%.

EXAMPLE 8

5 **3-Aminosteroid analogues prepared via the 22 aldehyde**



Alternate preparation of Compound 15



Preparation of Compound 13

Compound 1 (5.0 g, 15.2 mmol) was dissolved in dichloromethane (100 mL) and pyridinium chlorochromate (6.5 g, 30.0 mmol) was added to the reaction in one portion. After the reaction was magnetically stirred at room temperature for approximately six hours, the reaction was worked up by the gradual addition of a 5% sodium bisulfite solution. The organic layer was repeatedly washed with sodium bicarbonate solution and finally with brine. The organic layer was dried over sodium sulfate and the solvent removed *in vacuo* to yield compound 13 (4.3 g, 13.1 mmol, 86%) as an off white solid.

Preparation of Compound 16

Tetraethyl methylenediphosphonate (1.44 g, 5 mmol) was added to 10 mL anhydrous THF. Sodium *t*-butoxide (480 mg, 5 mmol) was added to the flask in one portion at rt. The solution was stirred for approximately thirty minutes to ensure complete formation of the phosphonate carbanion. Compound 13 (1.60 g, 4.8 mmol) was dissolved in minimal THF, and added to the reaction vessel dropwise via an addition funnel over five minutes. The reaction was allowed to stir for thirty minutes at room temperature. The reaction was worked-up by the addition of 50/50 toluene/ethyl acetate (50 mL). The organic layer was repeatedly washed with 0.1 M NaOH solution and then brine. The organic layer was dried over sodium sulfate and the solvent removed *in vacuo* to yield compound 16 (1.48 g, 3.2 mmol, 67%) as a white crystalline solid.

Preparation of Compound 17

Compound 16 (1.48 g, 3.2 mmol) was dissolved ethyl acetate (50 mL) and added to Parr flask. The flask was purged with nitrogen and 5% palladium on carbon (280 mg) was added to the flask. The flask was evacuated and filled with H_2 at 50 psi. The flask was shaken at room temperature overnight (approximately fourteen hours). The reaction was worked-up by filtering through a bed of Celite-7® and thoroughly washing the filter cake with ethyl acetate. The filtrate was evaporated *in vacuo* to give compound 17 as a white crystalline solid (1.41 g, 3.1 mmol, 97%).

Preparation of Compound 19

The phosphonate carbanion was prepared by the addition of 2-(diethylphosphono)-butyrolactone (25 g, 120 mmol) (prepared by heating a neat mixture of 2-bromobutyrolactone and triethylphosphite) to THF (1.2 L). Sodium *tert*-butoxide (11.5 g, 120 mmol) was added with ice bath cooling. The reaction was allowed to warm to room temperature over thirty minutes to insure complete formation of the phosphonate carbanion. Compound 18 (25.0 g,

76.2 mmol) was dissolved in THF (200 mL) and added to the reaction mixture, which was then warmed to reflux for approximately sixteen hours. The reaction was worked-up by removal of some THF (~700 mL) *in vacuo*. Toluene (500 mL) was then added and the solution washed repeatedly with 0.1 M NaOH solution and then brine. The organic layer was dried over sodium sulfate and the solvent removed *in vacuo*. The resulting solid was recrystallized from hexane/ethyl acetate to yield the mixed E,Z-isomers 19 as an off white solid (25.7 g, 64.5 mmol, 85%).

Preparation of Compound 15

Compound 19 (23.0 g, 57.8 mmol) was dissolved in THF/toluene 3/1 (~1 L). The solution was then added to ammonia (1.2 L) at -78°C. Lithium wire was added to the reaction until a deep blue color persisted. The reaction was warmed to reflux for thirty minutes, chilled back to -78°C, and then quenched by the addition of ammonium chloride. The ammonia was allowed to boil off overnight. The residue was acidified by the addition of 1.0 M HCl solution (500 mL) with aggressive stirring and an additional portion of toluene (500 mL) was added. There was a significant amount of insoluble material at the organic aqueous interface so the material was filtered through Celite-7®. The filtrate was added to a separatory funnel and the organic layer was washed with repeatedly with 0.1 M HCl, followed by sodium bicarbonate solution and brine. The organic layer was dried over sodium sulfate and the solvent removed *in vacuo* to yield compound 15 as a mixture of isomers at C23 (14.3 g, 36.2 mmol, 63%).

Reductive Aminations of Compounds 15 and 17

The 3-aminosteroid analogues prepared from compounds 15 and 17, compounds J, K, L and M are depicted in Figure 5. The reactions and isolations for these compounds were all virtually identical to those described previously for the preparation of compounds F, G, H and I. The only changes being the scale at which various preparations were run and the polyamine which was used; ethylenediamine was replaced with homopiperazine in one case (Compound-M).

Analytical for Compounds J, K, L and M

Compound-J: ^{1}H NMR (400 MHZ, CD_3OD): 0.74 (s, 3H), 0.90 (s, 3H), 1.04 (d, 3H, J=6.7 Hz), 2.45 (m, 1H), 2.64 (m, 1H), 3.17 (m, 1H) 3.68 (m, 1H), 4.21 (m,1H), 4.30 (m,1H); MS (FAB) $[M+H]^+$: 445; Anal. Calcd. for $C_{28}H_{48}N_2O_2$-2TFA-1.0H_2O: C 55.64 %, H 7.59 %, N 4.06 %. Found: C 55.75 %, H 7.41 %, N 4.17%.

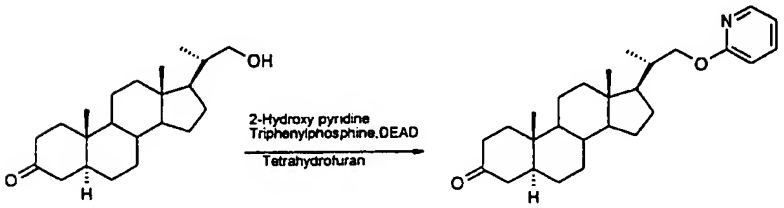
Compound-K: ^{1}H NMR (400 MHZ, DMSO-d_6): 0.74 (s, 3H), 0.90 (s, 3H), 1.04 (d, 3H, J=6.7 Hz), 2.35 (m, 1H), 2.60 (m, 1H), 3.17 (sharp m, 4H), 4.12 (m, 1H), 4.26 (m,1H); MS (FAB) $[M+H]^+$: 445; Anal. Calcd. for $C_{28}H_{48}N_2O_2$-2TFA-1.0H_2O: C 55.64 %, H 7.59 %, N 4.06 %. Found: C 55.43 %, H 7.63 %, N 4.10%.

Compound-L: ^{1}H NMR (400 MHZ, DMSO-d_6): 0.72 (s, 3H), 0.80 (s, 3H), 0.94 (d, 3H, J=6.7 Hz), 1.21 (t, 6H, J=6.7 Hz), 3.10-3.25 (m, 4H), 3.95 (d of q, 4H, J_1=6.7 Hz, J_2=2 Hz); MS (FAB) $[M+H]^+$: 511; Anal. Calcd. for $C_{29}H_{55}N_2O_3P$-2TFA-1.0H_2O: C 52.37 %, H 7.86 %, N 3.70 %. Found: C 52.58 %, H 7.82 %, N 3.53%.

Compound-M: ^{1}H NMR (400 MHZ, DMSO-d_6): 0.72 (s, 3H), 0.79 (s, 3H, 2 signals from mixed diastereomers), 0.94 (d, 3H, J=6.7 Hz, 2 signals), 2.31 (m, 1H), 2.55 (m, 1H), 3.15-3.72 (m, 8H), 4.10 (m, 1H), 4.26 (m, 1H); MS (FAB) $[M+H]^+$: 485; Anal. Calcd. for $C_{31}H_{52}N_2O_2$-2TFA-2.0H_2O: C 56.14 %, H 7.81 %, N 3.74 %. Found: C 56.34 %, H 7.14 %, N 3.79 %.

EXAMPLE 9

3-Aminosteroids prepared via Mitsunobu Reaction with compound 1



(1) (24)

Preparation of Compound 24

Compound 1 (5.0 g, 15.0 mmol) was dissolved in anhydrous THF (75 mL), and was treated with 2-hydroxypyridine (1.7 g, 18.0 mmol) and triphenylphosphine (4.7 g, 18.0 mmol). Diethylazodicarboxylate, DEAD, (3.1 g, 18.0 mmol) was added to the flask dropwise via an addition funnel. The addition of the DEAD caused an exothermic reaction. The reaction was allowed to stir at room temperature for thirty minutes before the solution was reduced in volume and applied directly to a 6 × 10 cm silica gel column (elution with 20 % ethyl acetate in toluene). The fractions containing pure compound 24 were pooled and the solvent removed *in vacuo* to yield a white crystalline solid (3.7 g, 9.1 mmol, 61%).

EXAMPLE 10

Preparation of Compounds N, O, and P

Compounds N, O, and P (Figure 6) were prepared by the same reductive amination procedure described previously.

Analytical for Compounds N, O and P

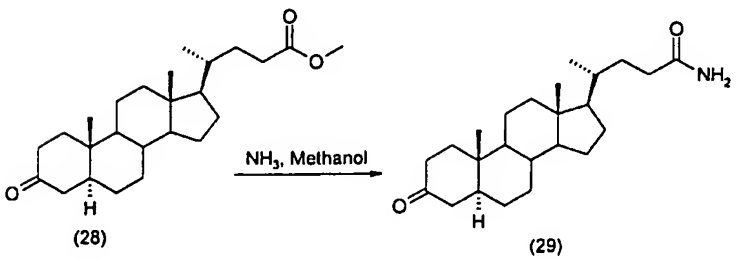
Compound-N: ^{1}H NMR (400 MHZ, CD_3OD): 0.69 (s, 3H), 0.83 (s, 3H), 1.05 (d, 3H, J=6.7 Hz), 3.14 (m, 4H), 3.96 (d of d, 1H, J_1=10 Hz, J_2=2 Hz), 4.24 (d of d, 1H, J_1=10 Hz, J_2=3 Hz), 6.70 (m,1H), 6.86 (m,1H), 7.60 (m,1H), 8.14 (m ,1H); MS(+FAB): $[M+H]^+$ 454; Anal. Calcd. for $C_{29}H_{47}N_3O$-2TFA-3H_2O: C 53.87%, H 7.53%, N 5.71%. Found: C 53.72%, H 6.61%, N 5.85%.

Compound-O: ^{1}H NMR (400 MHZ, DMSO-d_6): 0.70 (s, 3H), 0.81 (s, 3H), 1.07 (d, 3H, J=6.7 Hz), 3.15 (m, 4H), 3.94 (d of d, 1H, J_1=10 Hz, J_2=2 Hz), 4.25 (d of d, 1H, J_1=10 Hz, J_2=3 Hz), 6.70 (m, 1H), 6.85 (m, 1H), 7.60 (m, 1H), 8.14 (m, 1H); MS(+FAB): $[M+H]^+$ 454; Anal. Calcd. for $C_{29}H_{47}N_3O$-2TFA-3H_2O: C 55.22%, H 7.44%, N 5.85%. Found: C 55.12%, H 6.74%, N 5.95%.

Compound-P: ^{1}H NMR (400 MHZ, DMSO-d_6): 0.70 (s, 3H), 0.81 (s, 3H), 1.14 (d, 3H, J=6.7 Hz), 2.90 (m, 4H), 4.04 (d of d, 1H, J_1=10 Hz, J_2=2 Hz), 4.25 (d of d, 1H, J_1=10 Hz, J_2=3 Hz), 6.70 (m, 1H), 6.85 (m, 1H), 7.60 (m, 1H), 8.14 (m, 1H); MS(+FAB): $[M+H]^+$ 480; Anal. Calcd. for $C_{29}H_{47}N_3O$-3TFA-1H_2O: C 52.92%, H 6.48%, N 5.00%. Found: C 53.18%, H 5.88%, N 4.22%.

EXAMPLE 11

Preparation of 24-amide



(28) (29)

Preparation of Compound 29

Compound 28 (1.0 g, 2.6 mmol) was dissolved in methanol (50 mL). The solution was chilled to 0°C and ammonia was bubbled into the reaction vessel for thirty minutes. The reaction was sealed and allowed to stir at room temperature for two weeks. The reaction was worked-up by chilling the reaction to -20°C, opening the sealed tube, and then allowing the reaction to warm to room temperature. After the excess ammonia had evaporated, the remainder of the methanolic ammonia was removed *in vacuo* to yield compound 29 (0.95 g, 2.5 mmol, 96%).

Preparation of Compound-Q (Figure 7)

The 3-aminosteroid analogue of compound 29 was prepared by same methods described earlier for the preparation of the other 3-aminosteroid analogues.

Compound-Q: ^{1}H NMR (400 MHZ, CD_3OD): 0.74 (s, 3H), 0.93 (s, 3H), 0.98 (d, 3H, J=6.7 Hz), other downfield signals buried in the solvent peak; MS (+FAB): $[M+H]^+$ 418; Anal. Calcd. for $C_{29}H_{47}N_3O$-2TFA-0.7H_2O: C 54.73%, H 7.72%, N 6.38%. Found: C 54.70%, H 7.51%, N 6.18%.

While the invention has been described and illustrated herein by references to various specific materials, procedures and examples, it is understood that the invention is not restricted to the particular material combinations of material and procedures selected for that purpose. Numerous variations of such details can be implied as will be appreciated by those skilled in the art.

Other embodiments of the invention described above and will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed within. All cited patents and publications referred to in this application are herein incorporated by reference in their entirety. It is intended that the specification and examples considered as exemplary only, with true scope and spirit of the invention being indicated by the following claims:

Table 1

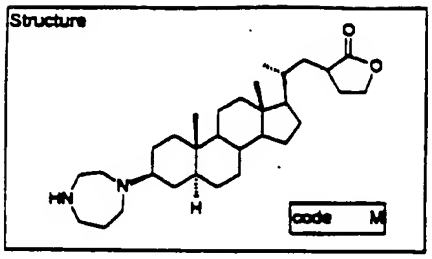
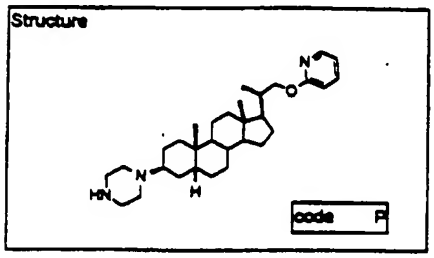
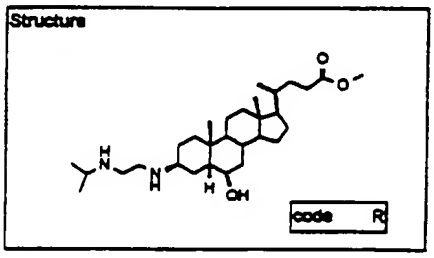
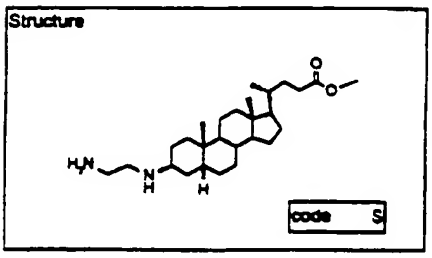
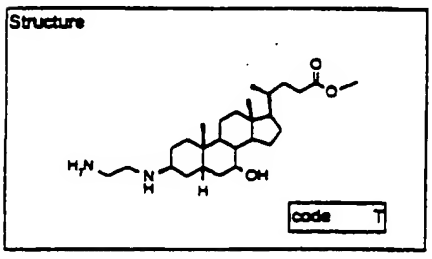
Structure	Aggregation Assay Minimum Effective Conc. (μg/mL)	PBMC Proliferation ASSAY IC50 (μ g/mL)
	10	
	> 10	
		0.24
	10	<0.1 (toxic)
	10, 5	2.77

Table 1

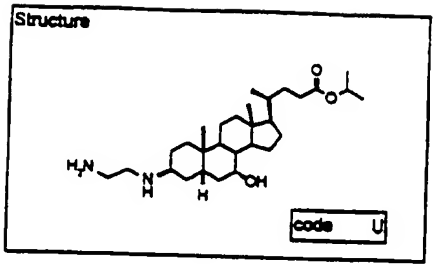
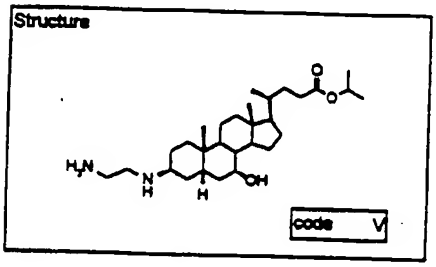
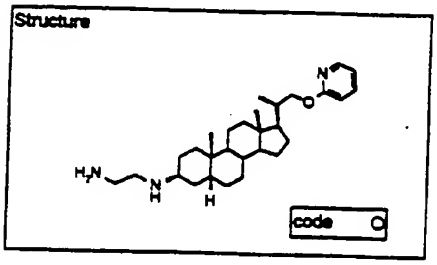
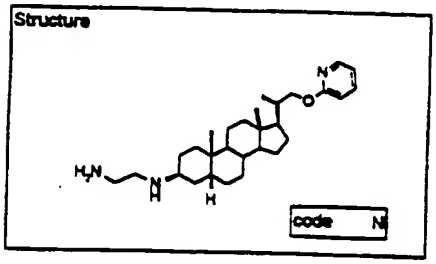
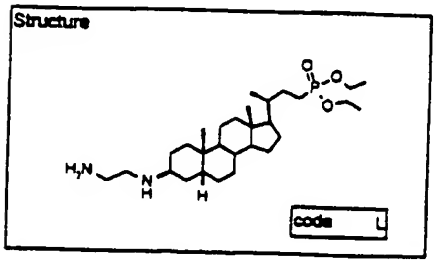
Structure	Aggregation Assay Minimum Effective Conc. (μg/mL)	PBMC Proliferation ASSAY IC50 (μ g/mL)
 code U	1 - 10	0.40
 code V	10	0.41
 code Q	10	0.25
 code N	1-10	0.06
 code L	10	0.22

Table 1

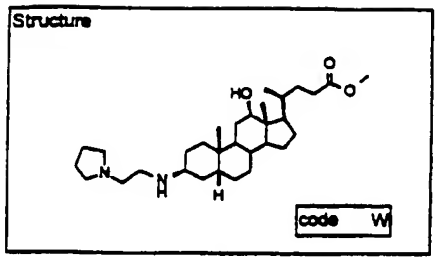
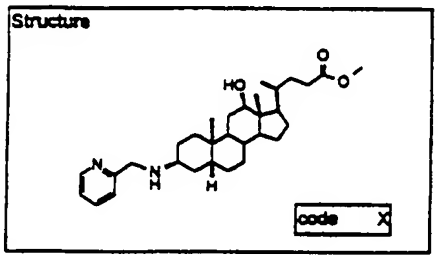
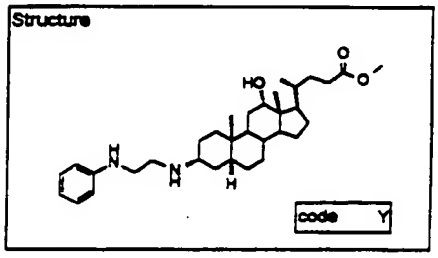
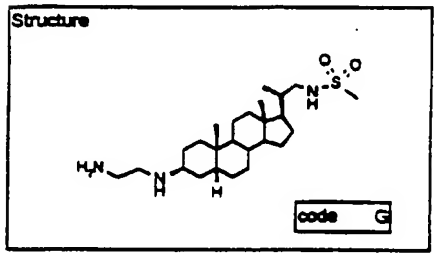
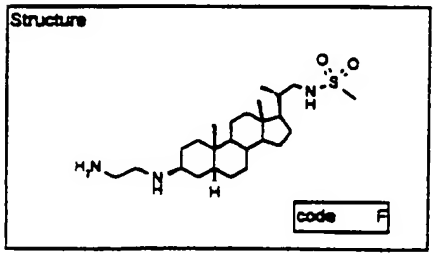
Structure	Aggregation Assay Minimum Effective Conc. (μg/mL)	PBMC Proliferation ASSAY IC50 (μ g/mL)
 code W	10	
 code X	10	
 code Y	10	
 code G	10	
 code F	10, 5	2.88

Table 1

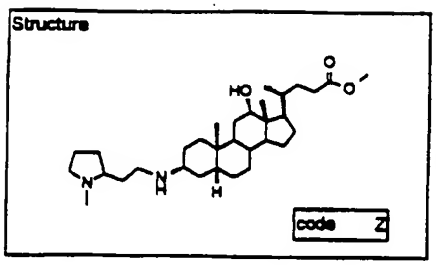
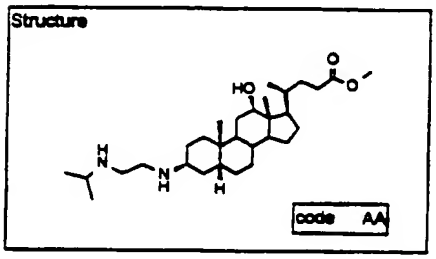
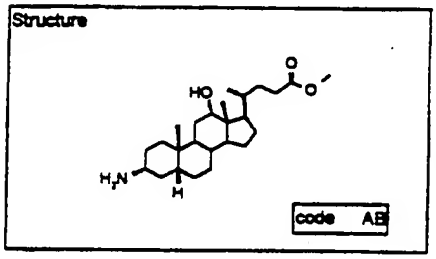
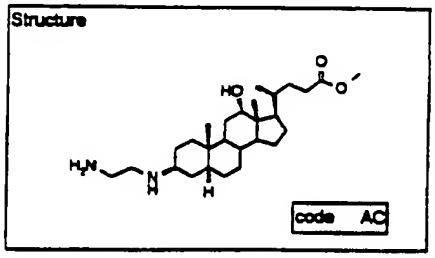
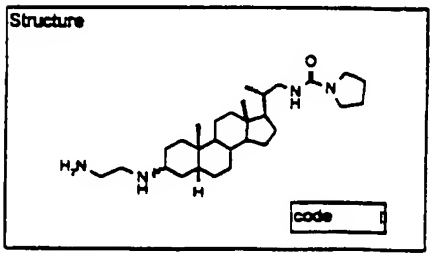
Structure	Aggregation Assay Minimum Effective Conc. (μg/mL)	PBMC Proliferation ASSAY IC50 (μ g/mL)
 code Z	10, 5	0.71
 code AA	10, 5	0.42
 code AB	10, 5	2.54
 code AC	10, 5	0.47
 code	10, 1	0.23

Table 1

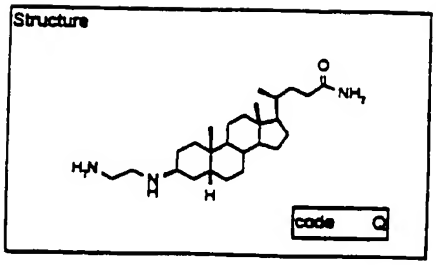
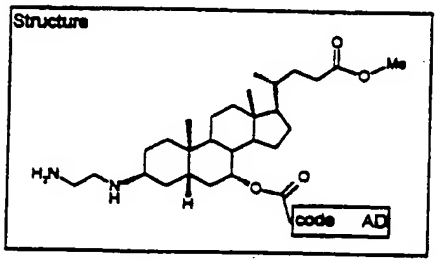
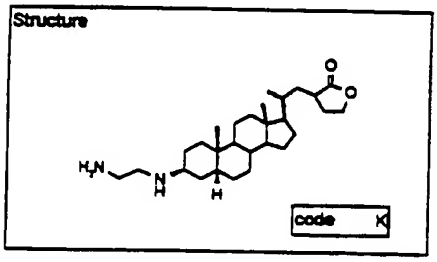
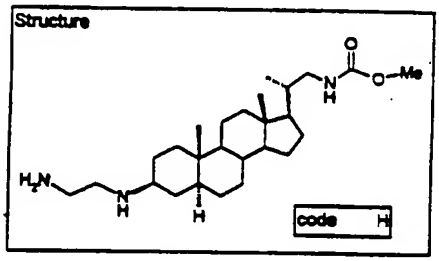
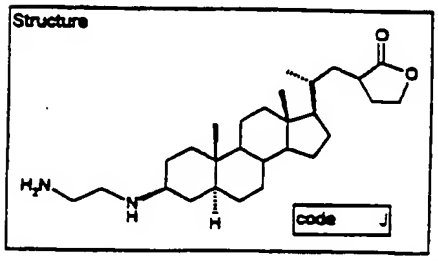
Structure	Aggregation Assay Minimum Effective Conc. (μg/mL)	PBMC Proliferation ASSAY IC50 (μ g/mL)
 code Q	10, 5	2.42
 code AD	10, 5	0.29
 code K	10 (+/-), 5	0.31
 code H	10, 0.5	0.26, 0.44
 code J	1	0.03

Table 1

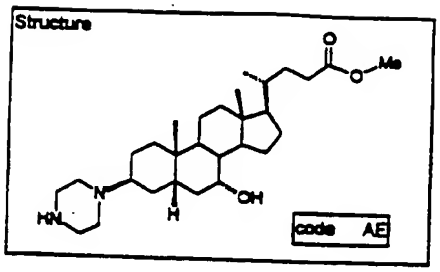
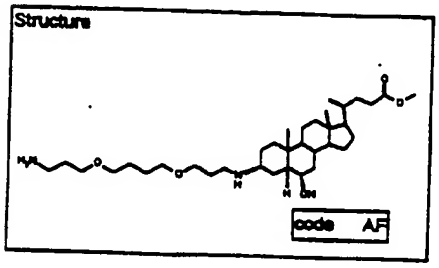
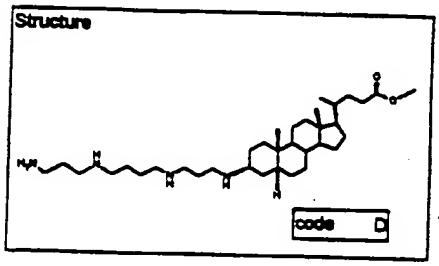
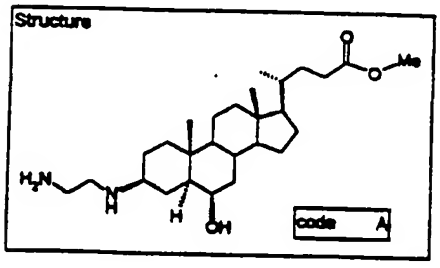
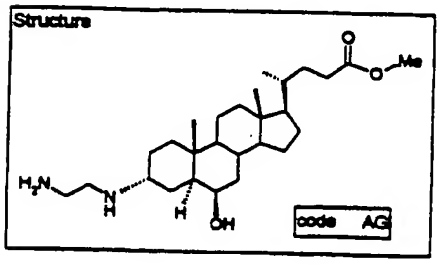
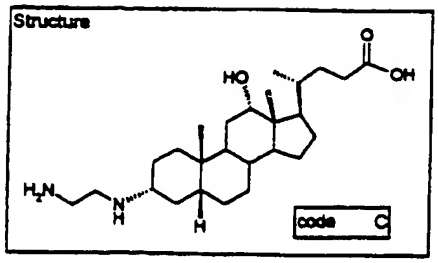
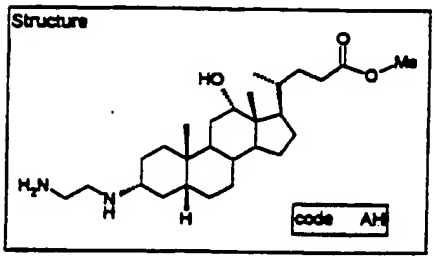
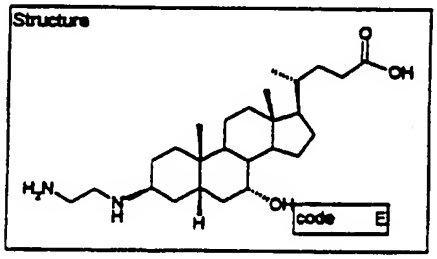
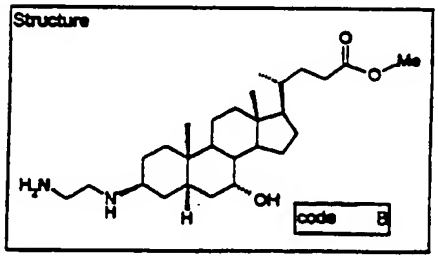
Structure	Aggregation Assay Minimum Effective Conc. (μg/mL)	PBMC Proliferation ASSAY IC50 (μ g/mL)
 code AE	10, 5	0.28
 code AF	10, 5	2.41
 code D	10	
 code A	1	
 code AG	10	

Table 1

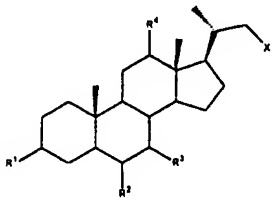
Structure	Aggregation Assay Minimum Effective Conc. (μg/mL)	PBMC Proliferation ASSAY IC50 (μ g/mL)
	>10	
	1	0.1
	>10	
	10, 5	0.41, 2.35, 0.75

What is claimed:

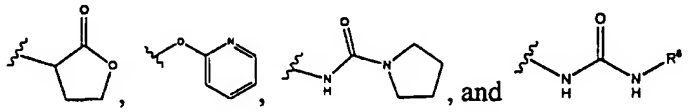
1. A method of treating atopic allergy and asthma in a mammal comprising administering an effective amount of a 3-aminosteroid compound.

2. The method of claim 1 wherein the 3-aminosteroid compound down-regulates IL-9.

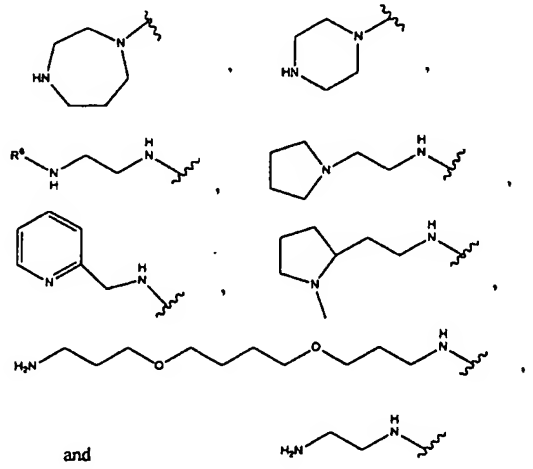
3. The method of claim 1, wherein said compound has the following chemical formula:



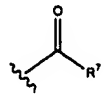
wherein X is selected from the group consisting of —CH_2—$PO(OR^5)_2$, —NH—SO_2—R^5, —NH—CO—OR^5, —CH_2—CO—NH_2, —CH_2—CO—NH—R^8, —CH_2—CO_2—R^5,



R^1 is selected from the group consisting of R^6—NH_2—,

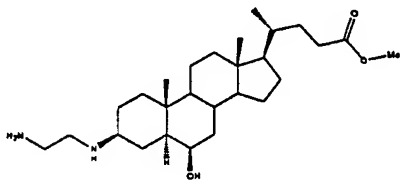


R^2, R^3, and R^4 are each independently selected from the group consisting of H, —OH, —OAc,

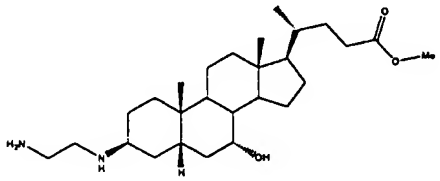
and 

R^5 is a C_{1-12} alkyl, and R^6, R^7 and R^8 are each independently selected from the group consisting of H, C_{1-6} alkyl, and phenyl.

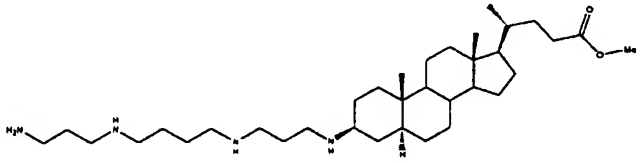
4. The method of claim 1, wherein said compound has the following chemical formula:



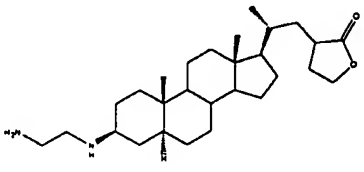
5. The method of claim 1, wherein said compound has the following chemical formula:



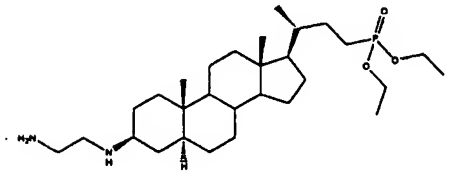
6. The method of claim 1, wherein said compound has the following chemical formula:



7. The method of claim 1, wherein said compound has the following chemical formula:



8. The method of claim 1, wherein said compound has the following chemical formula:



9. A method for identifying an immunomodulatory 3-aminosteroid compound comprising:

(a) culturing peripheral blood lymphocytes in the presence of a 3-aminosteroid compound and a mitogen to form cell aggregates; and

(b) determining the number of cell aggregates;

wherein an immunomodulatory 3-aminosteroid compound reduces the number of cell aggregates when compared to peripheral blood lymphocytes cultured in the absence of the 3-aminosteroid compound.

10. A method for identifying an immunomodulatory 3-aminosteroid compound comprising:

(a) culturing peripheral blood lymphocytes in the presence of a 3-aminosteroid compound and a mitogen; and

(b) determining the level of IL-9 mRNA;

wherein an immunomodulatory 3-aminosteroid compound reduces the level of IL-9 mRNA when compared to peripheral blood lymphocytes cultured in the absence of the 3-aminosteroid compound.

11. The method of claim 9 or 10 wherein the peripheral blood lymphocytes are cultured in the presence of mitogen for about twelve hours.

12. A method for identifying an immunomodulatory 3-aminosteroid compound comprising:

(a) culturing peripheral blood lymphocytes isolated from an antigen-stimulated mammal in the presence of a 3-aminosteroid compound and an antigen to form cell aggregates; and

(b) determining the number of cell aggregates;

wherein an immunomodulatory 3-aminosteroid compound reduces the number of cell aggregates when compared to peripheral blood lymphocytes cultured in the absence of the 3-aminosteroid compound.

13. The method of claim 12 wherein the peripheral blood lymphocytes are cultured in the presence of antigen for about three days.

14. The method of claim 12 wherein the antigen-stimulated mammal is a mouse.

15. A method for identifying an immunomodulatory 3-aminosteroid compound comprising:

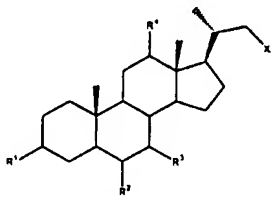
(a) culturing cells which proliferate in response to IL-9 in the presence of IL-9 and a 3-aminosteroid compound; and

(b) measuring the level of cell proliferation

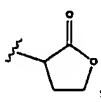
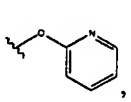
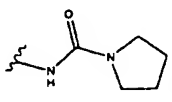
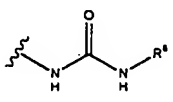
wherein an immunomodulatory 3-aminosteroid compound reduces the level of cell proliferation induced by IL-9 when compared to cells cultured in the absence of the 3-aminosteroid compound.

16. The method of claim 15 wherein the cells which proliferate in response to IL-9 are M07e cells.

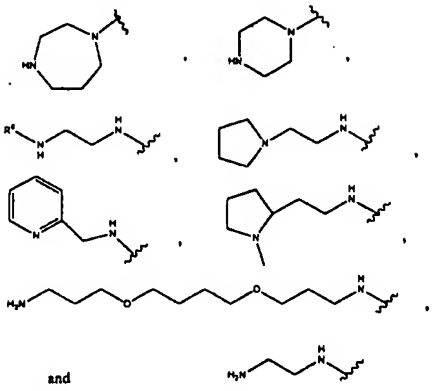
17. A compound having the formula:



wherein X is selected from the group consisting of —CH_2—$PO(OR^5)_2$, —NH—SO_2—R^5, —NH—CO—OR^5, —CH_2—CO—NH_2, —CH_2—CO—NH—R^8, —CH_2—CO_2—R^5,

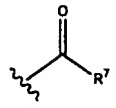
 ,  ,  , and 

R^1 is selected from the group consisting of R^6—NH_2—,



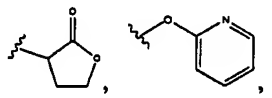
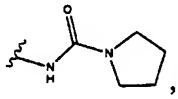
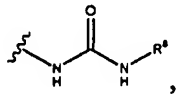
and

R^2, R^3, and R^4 are each independently selected from the group consisting of H, —OH, —OAc,

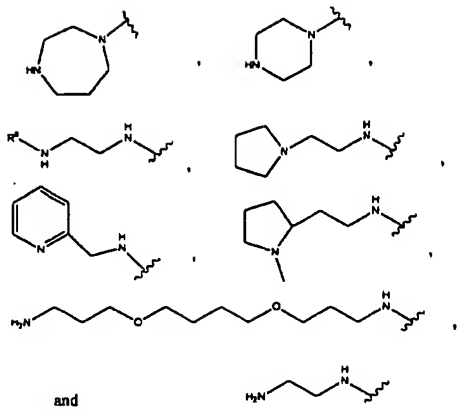
and 

R^5 is a C_{1-12} alkyl, and R^6, R^7 and R^8 are each independently selected from the group consisting of H, C_{1-6} alkyl and phenyl.

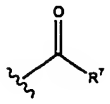
18. A compound of claim 12 wherein X is selected from the group consisting of —CH_2—$PO(OR^5)_2$, —NH—SO_2—R^5, —NH—CO—OR^5, —CH_2—CO—NH_2, —CH_2—CO—NH—R^8,

 , ,  , and  ,

R^1 is selected from the group consisting of R^6—NH_2—,



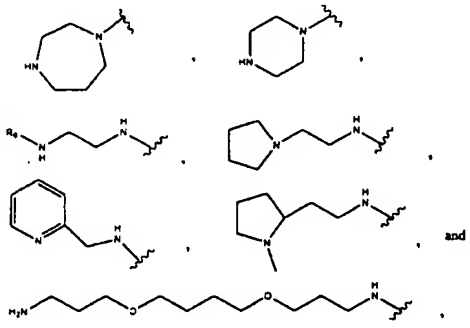
R^2, R^3, and R^4 are independently selected from the group consisting of H, —OH, —OAc, and



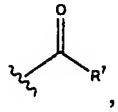
R^5 is a C_{1-12} alkyl, and R^6, R^7 and R^8 are independently selected from the group consisting of H, C_{1-6} alkyl, and phenyl.

19. A compound of claim 12, wherein X is —CH_2—CO_2—R^5,

R^1 is selected from the group consisting of: R^6—NH_2—,



R^2, R^3, and R^4 are independently selected from the group consisting of H, —OH, —OAc, and

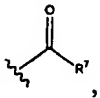
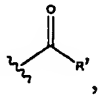


R^5 is a C_{1-12} alkyl, and R^6 and R^7 are each independently selected from the group consisting of H, C_{1-6} alkyl, and phenyl.

20. A compound of claim 12, wherein X is $—CH_2—CO_2—R^5$,

R^1 is  ,

R^2, R^3, and R^4 are each independently selected from the group consisting of H, —OH, —OAc,

and  , with the proviso that at least one of R^2, R^3, and R^4 is  ,

R^5 is a C_{1-12} alkyl, and R^7 is selected from the group consisting of H, C_{1-6} alkyl, and phenyl.

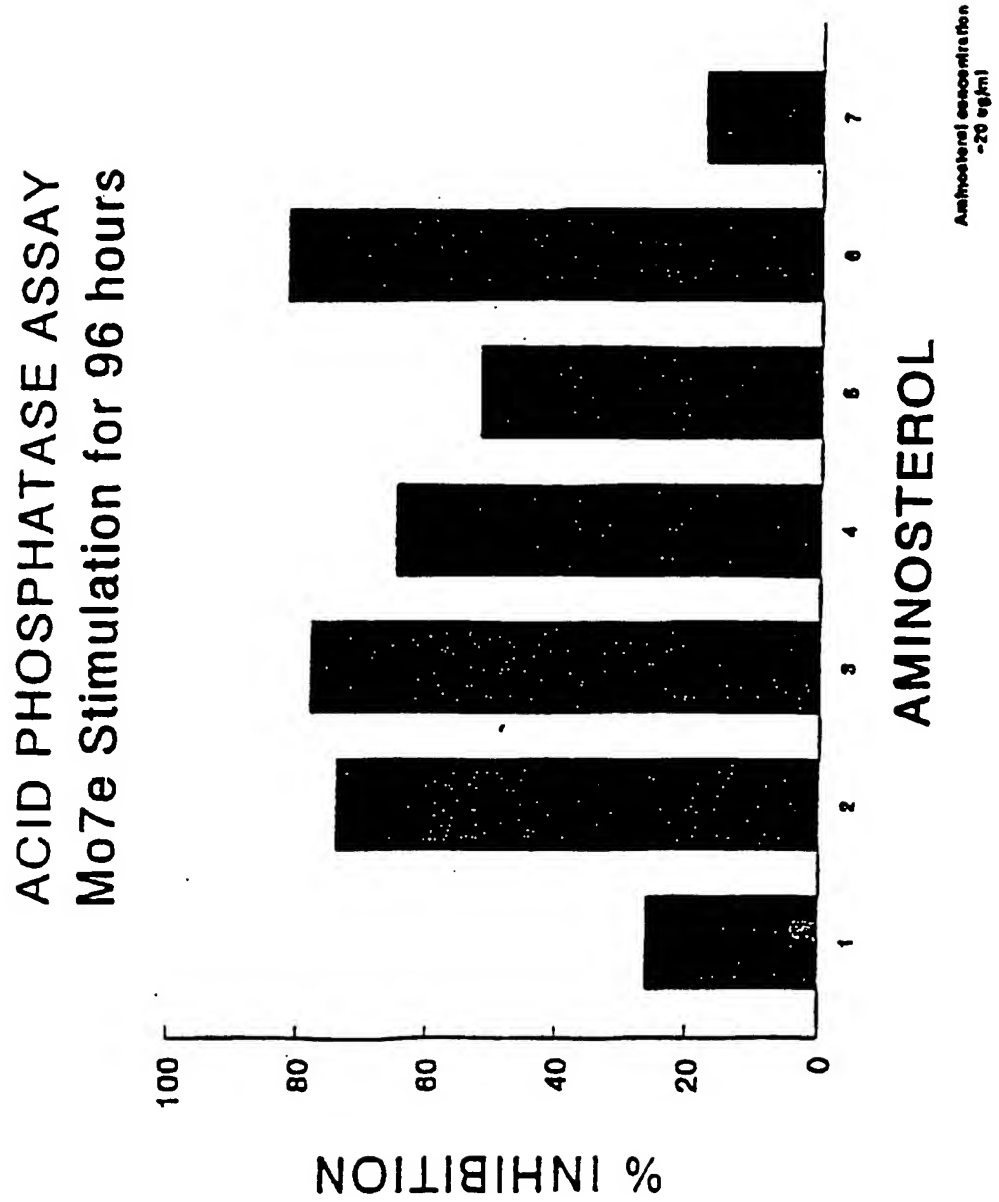
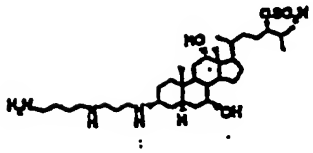

ACID PHOSPHATASE ASSAY
Mo7e Stimulation for 96 hours
% INHIBITION
100
80
60
40
20
0
1
2
3
4
5
6
7
AMINOSTEROL
Aminosterol concentration
~20 ug/ml

Figure 1

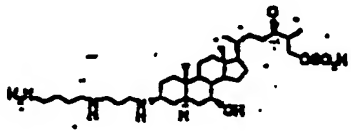
Name and Chemical Structure of Aminosterols

1. 1505

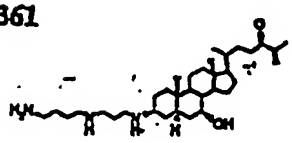


2. preSQLS-658 (not determined)

3. 1360



4. 1361



5. preSQHS-642 (not determined)

6. preSQHS-781 (not determined)

7. dessulfateSQ (not determined)

Figure 2

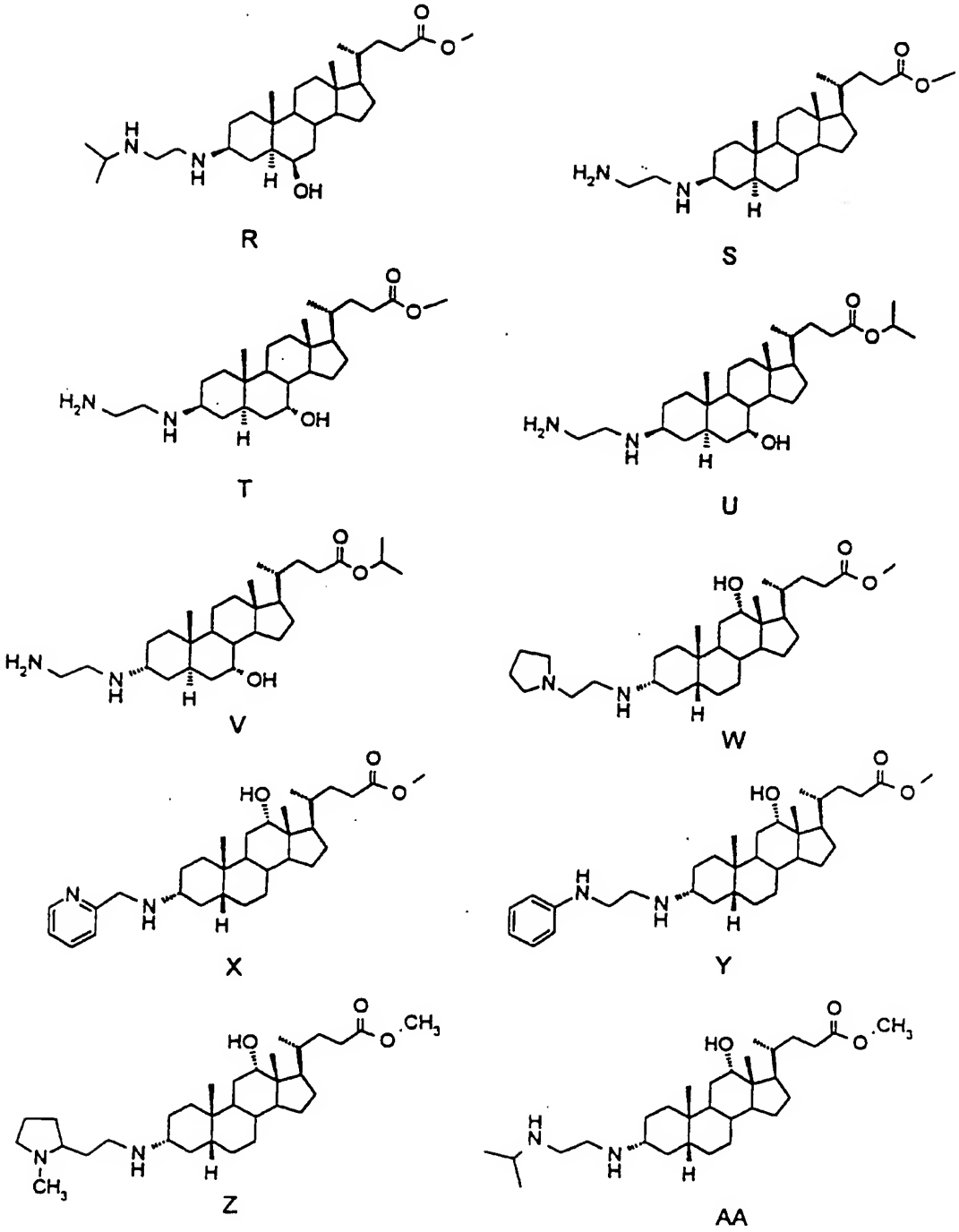


Figure 3

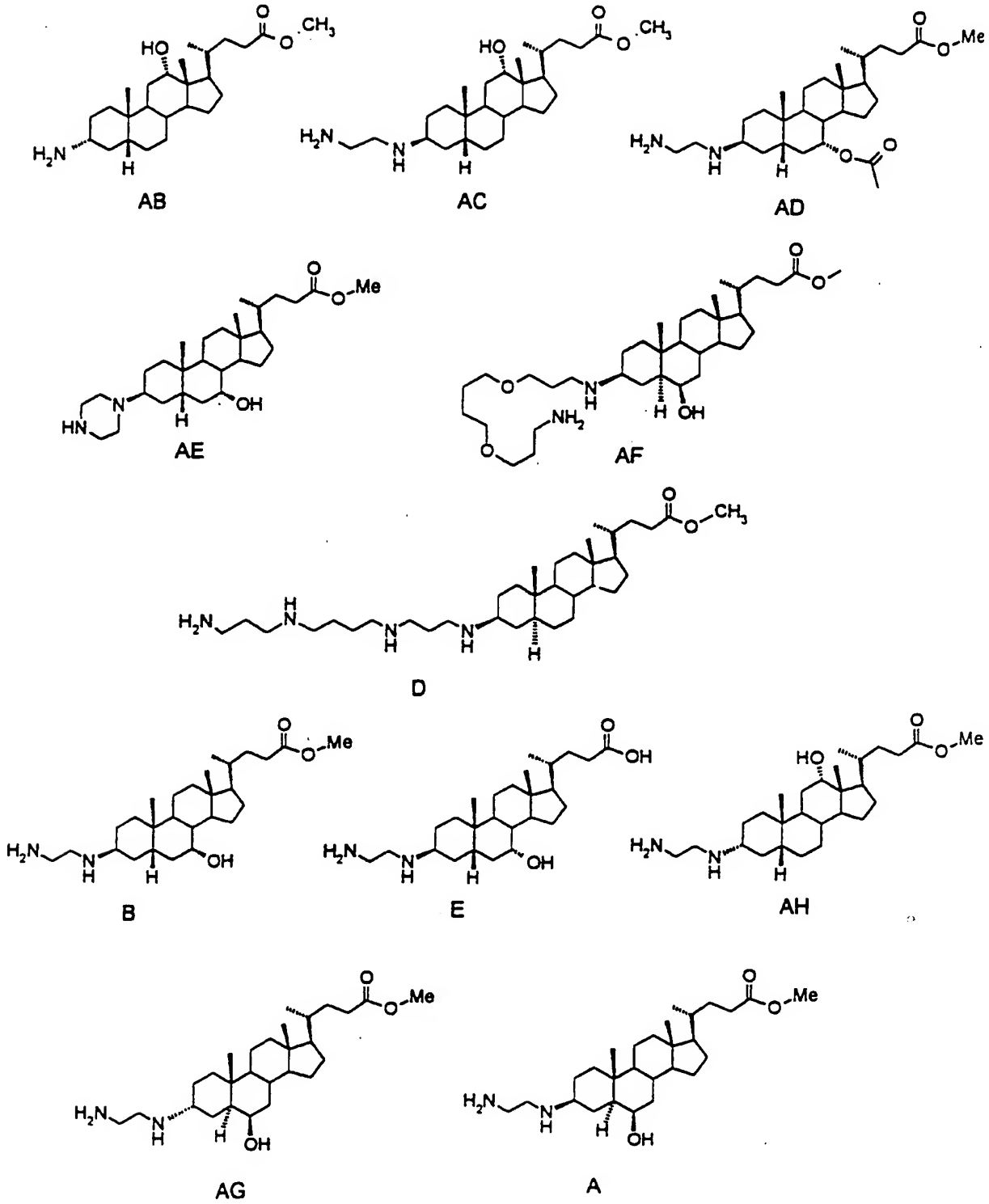


Figure 3 Cont.

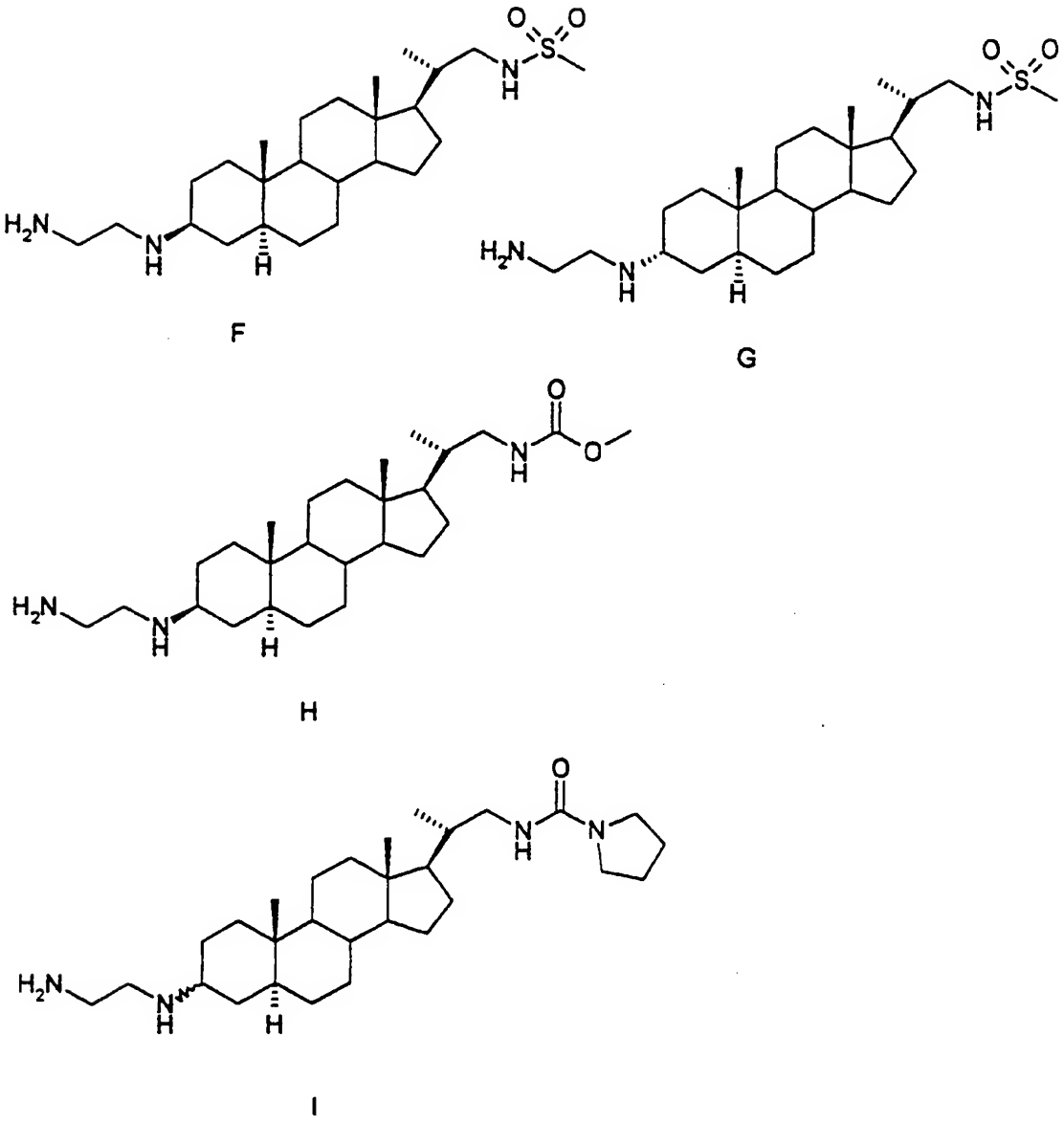


Figure 4

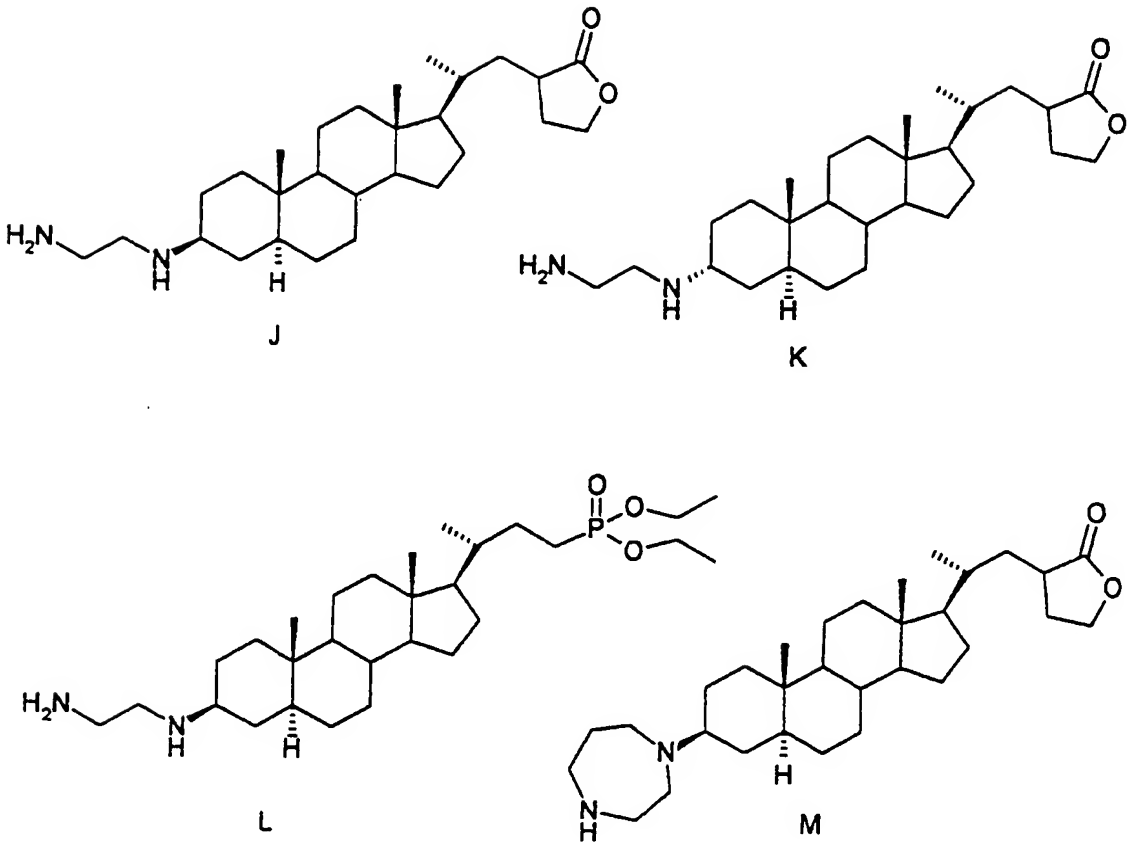
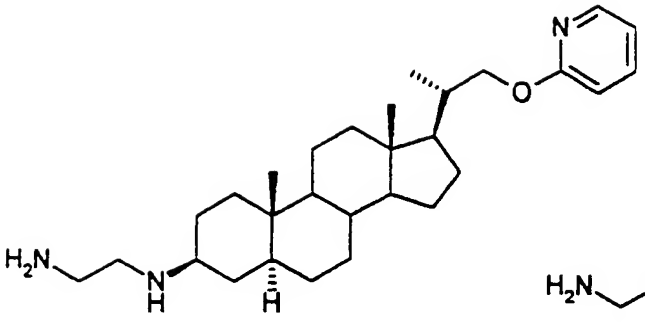
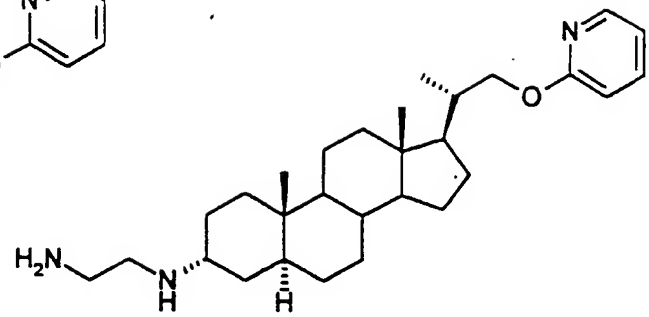


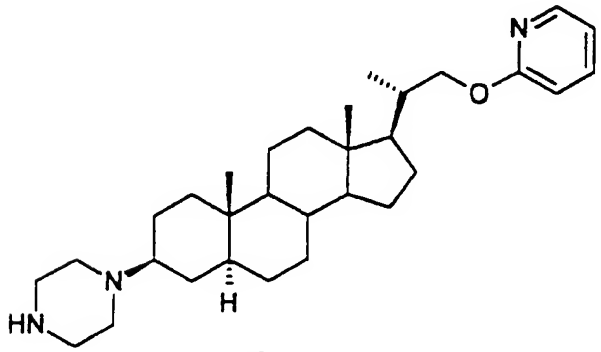
Figure 5



N

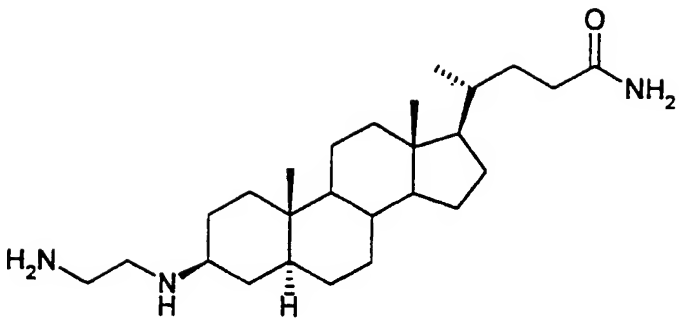


O



P

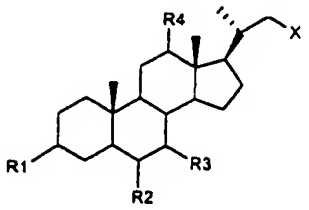
Figure 6

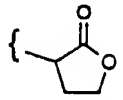


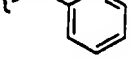
Q

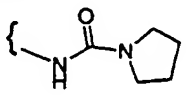
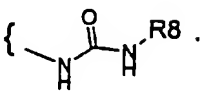
Figure 7

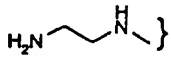
Novel Aminosteroids with Ester Isoteres

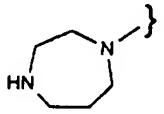
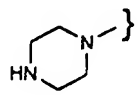
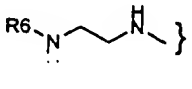
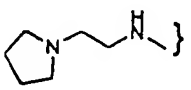
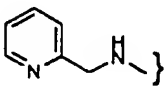
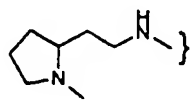
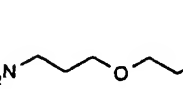
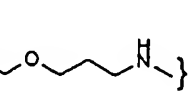


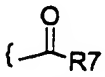
x =  , { $-CH_2-PO(OR5)_2$, { $-NH-SO_2-R5$

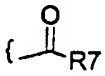
{ -NH-CO-OR5,  , { $-CH_2-CO-NH_2$,

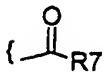
{ $-CH_2-CO-NH-R8$,  ,  .

R1=  R6-NH_2- }

R2= H, OH, OAc,  .

R3= H, OH, OAc,  .

R4= H, OH, OAc,  .

R5= C_1 to C_{12} alkyl.

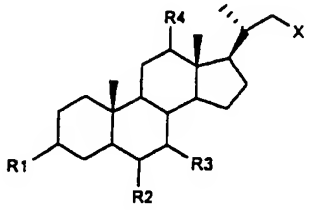
R6= H, C1 to C6 alkyl, phenyl.

R7= H, C1 to C6 alkyl, phenyl.

R8= H, C1 to C6 alkyl, phenyl.

Figure 8

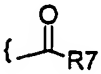
Novel Aminosteroid Esters with Modified Polyamines



x = {-CH_2-CO_2R5 .

R2= H, OH, OAc, {  .

R3= H, OH, OAc, {  .

R4= H, OH, OAc, {  .

R5= C_1 to C_{12} alkyl.

R6= H, C1 to C6 alkyl, phenyl.

R7= H, C1 to C6 alkyl, phenyl.

R1= R6-NH_2- }

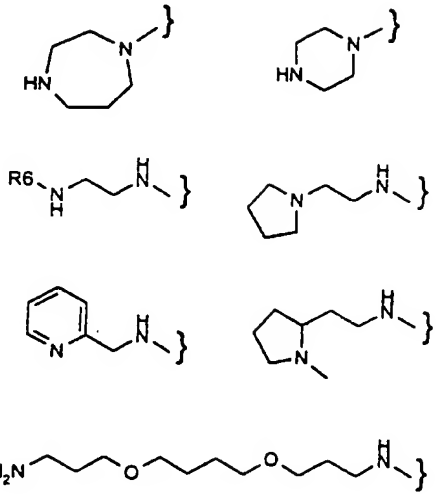
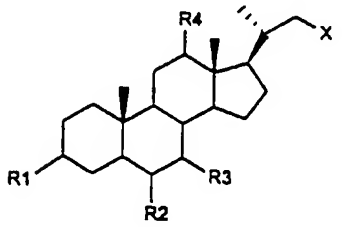


Figure 9

Novel Acylated Aminosteroid Esters



x = {-CH_2-CO_2-R5

R2= H, OAc, {O=C-R7 .

R3= H, OAc, {O=C-R7 .

R4= H, OAc, {O=C-R7 .

R1= {H_2N-CH$_2$-CH$_2$-NH-}

R5= C_1 to C_{12} alkyl.

R7= H, C1 to C6 alkyl, phenyl.

At least one of R2, R3, or R4 is {O=C-R7.

Figure 10

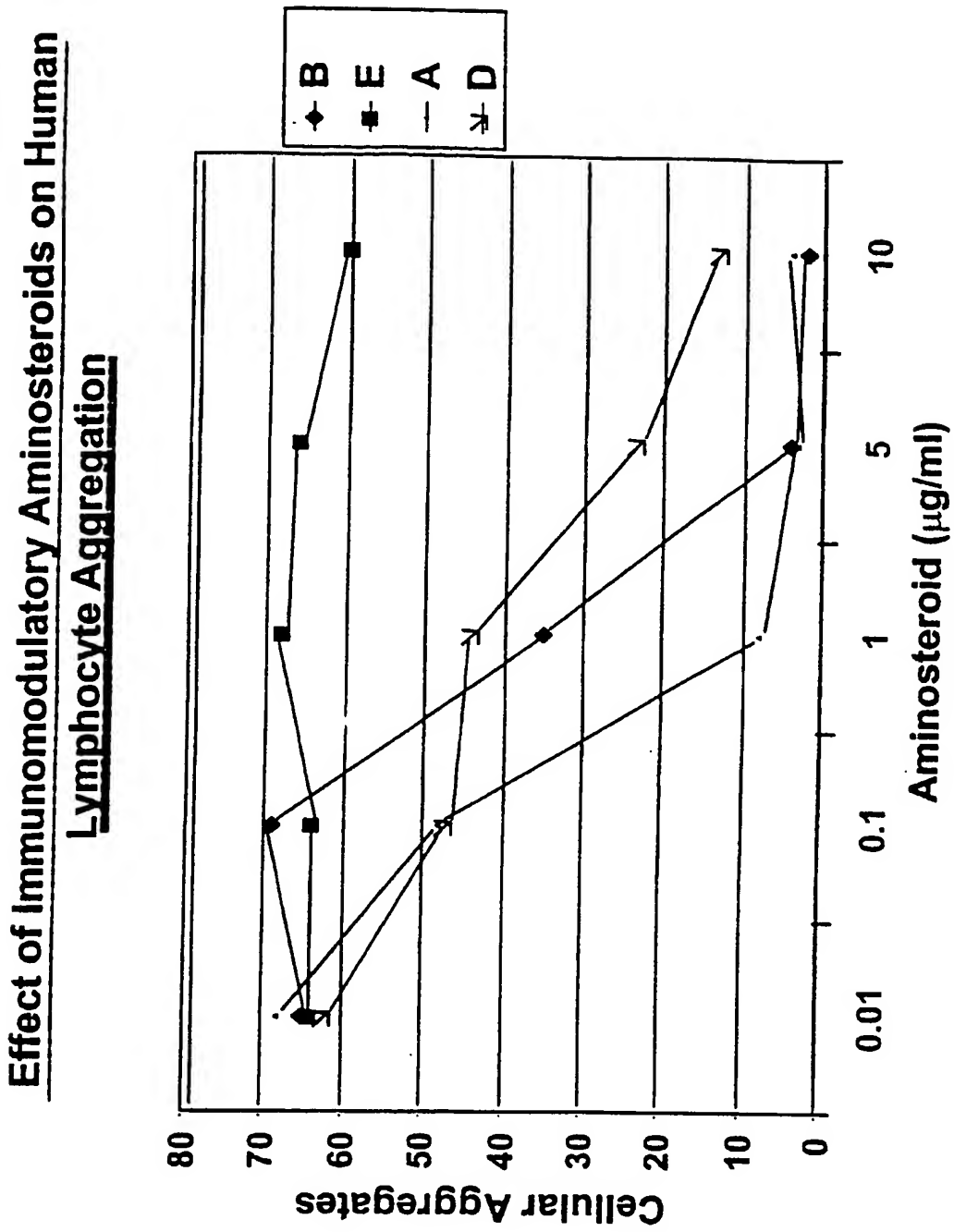

Effect of Immunomodulatory Aminosteroids on Human Lymphocyte Aggregation
B
E
A
D
Cellular Aggregates
0
10
20
30
40
50
60
70
80
0.01
0.1
1
5
10
Aminosteroid (μg/ml)

Figure 11

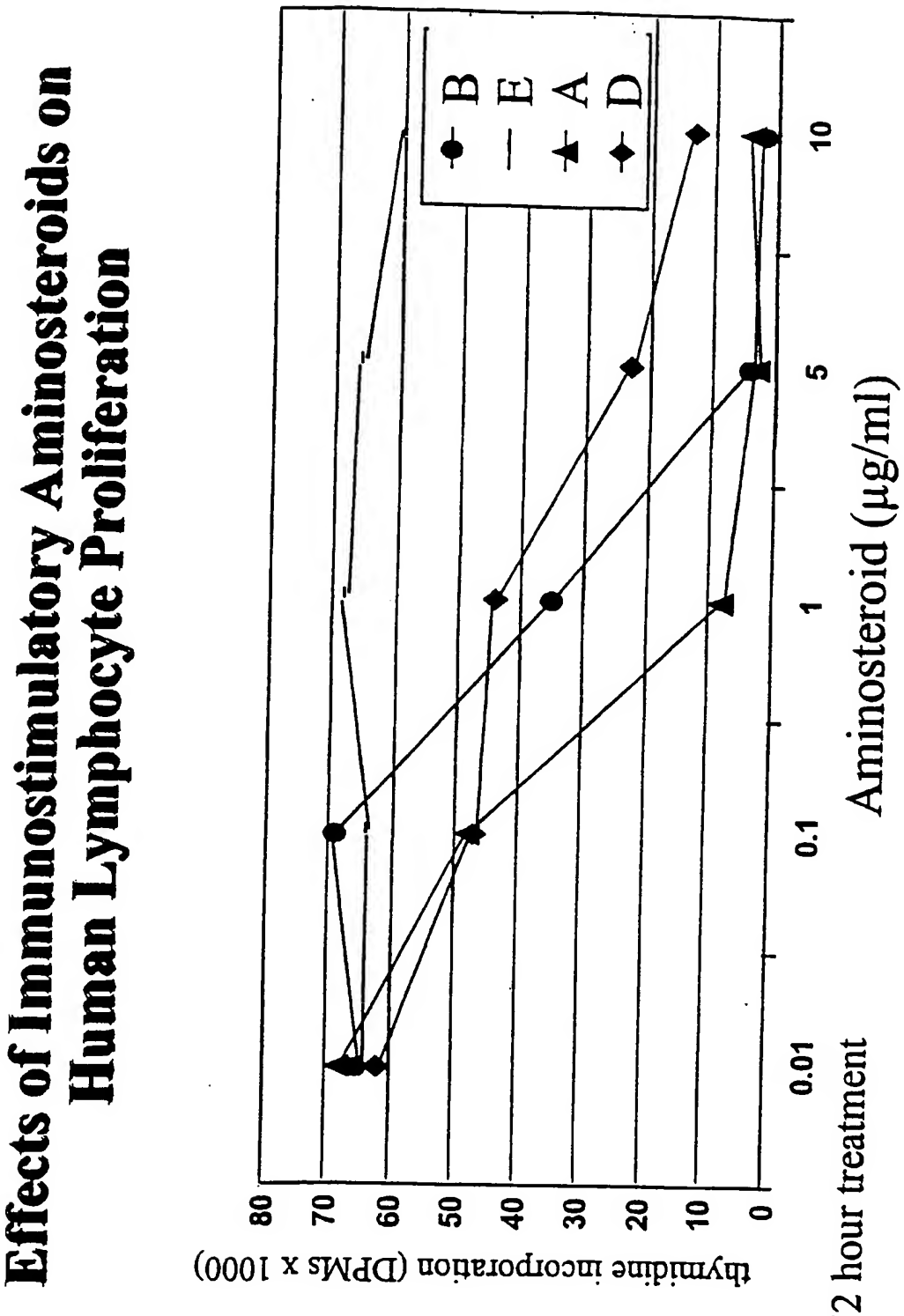

Effects of Immunostimulatory Aminosteroids on Human Lymphocyte Proliferation
thymidine incorporation (DPMs x 1000)
80
70
60
50
40
30
20
10
0
B
E
A
D
0.01
0.1
1
5
10
Aminosteroid (µg/ml)
72 hour treatment

Figure 12

Effects of Immunostimulatory Aminosteroids on IL-9 Expression in Mitogen-Stimulated Human Lymphocytes

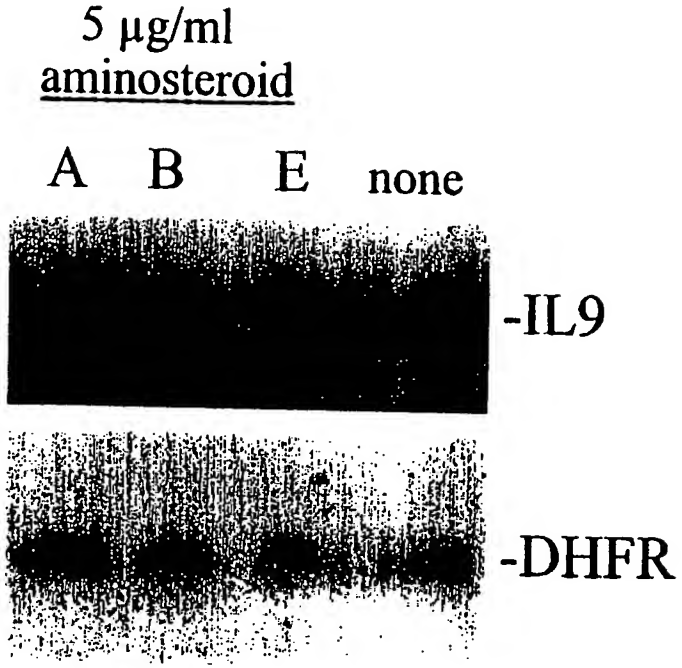


Figure 13

Aminosteroids Reverse Baseline BHR

Baseline Airway Hyperresponsiveness Blocked in Naïve Mice

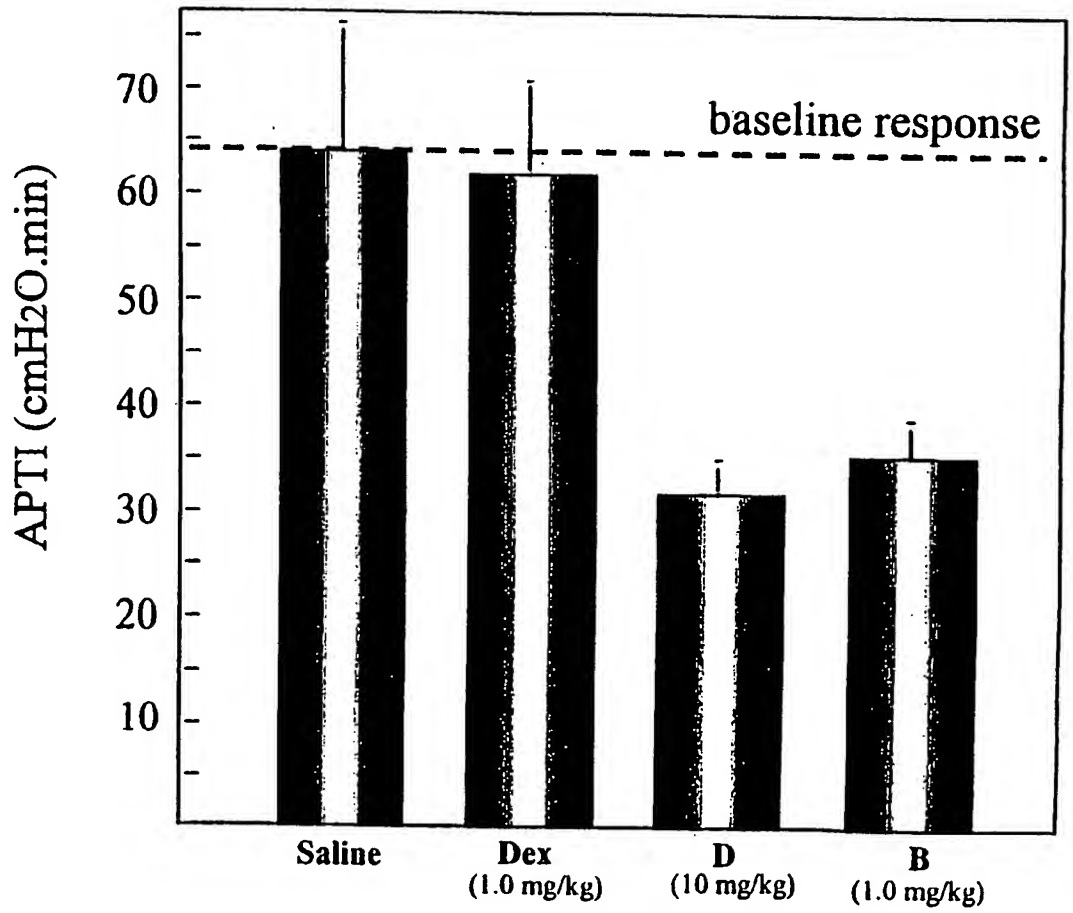
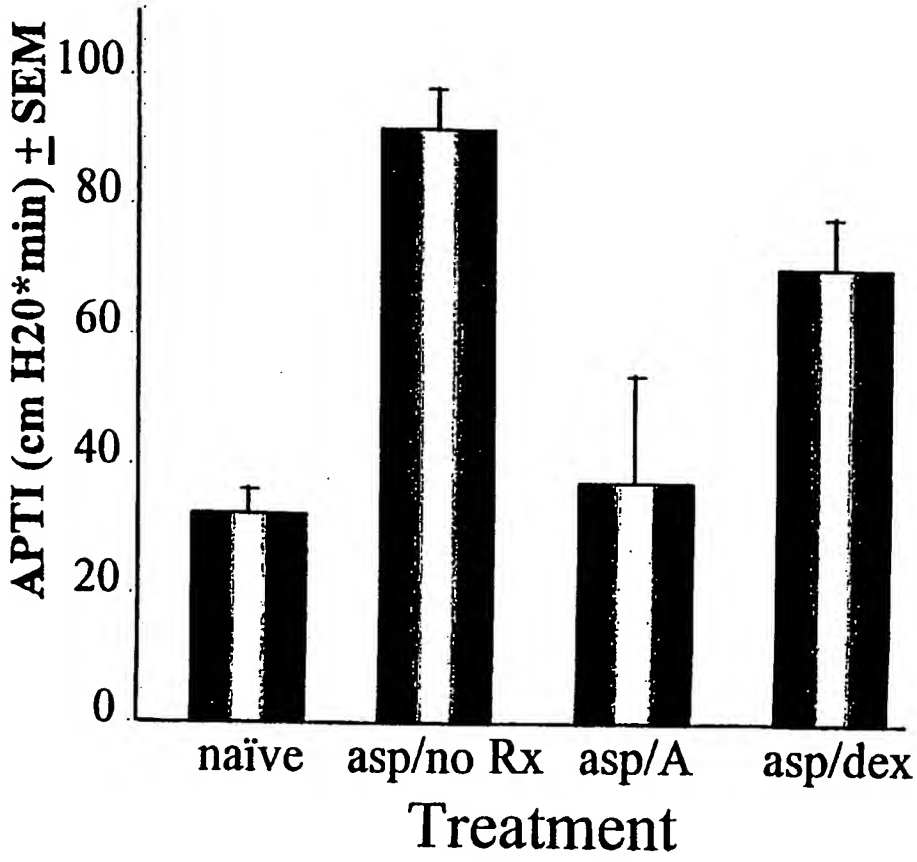


Figure 14

Effect of Compound A on AHR

Airway Hyperresponsiveness in *Aspergillus fumigatus* sensitized DBA/2J Mice



5-HT (58 µg/kg)

Figure 15

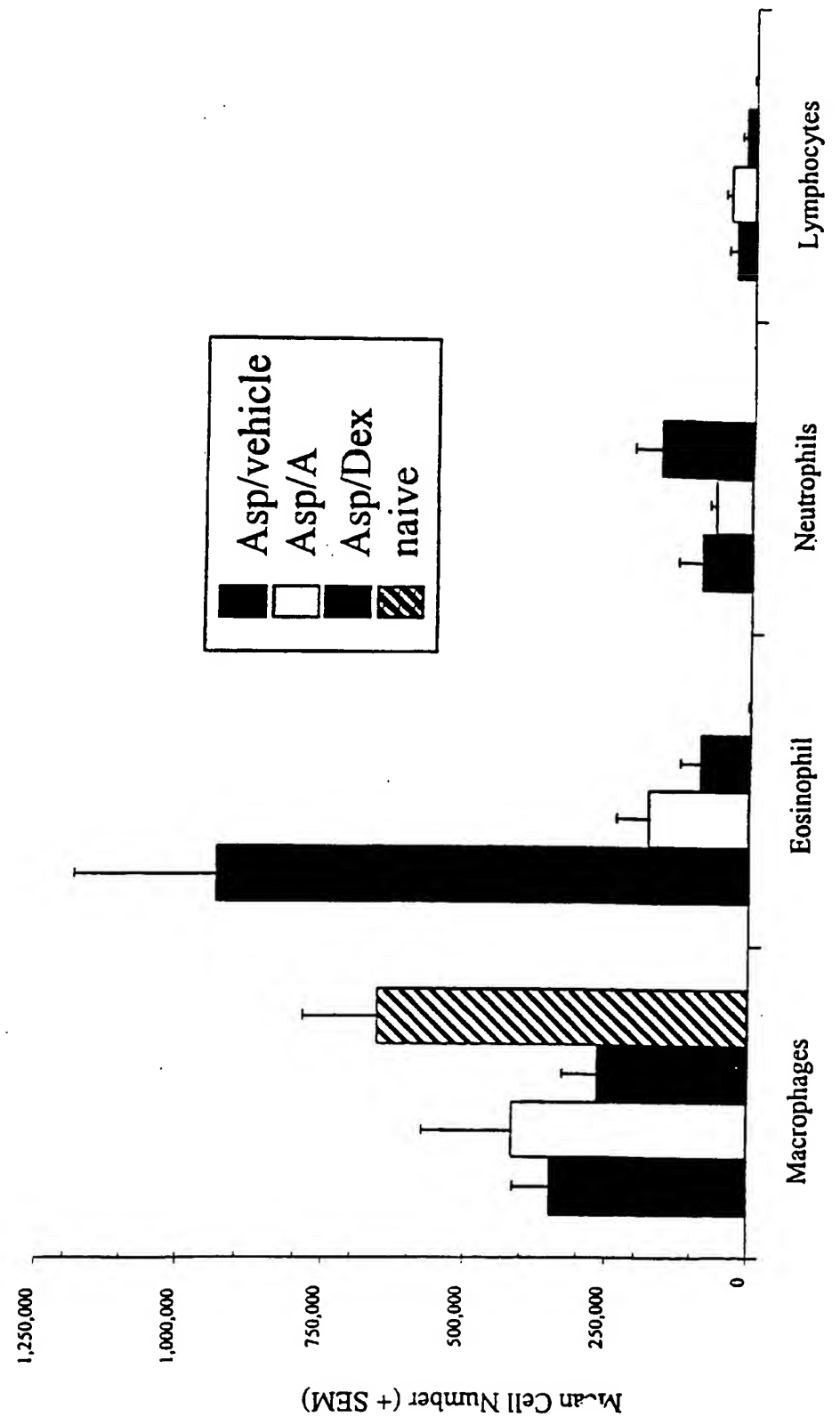

Aminosteroids: Anti-Inflammatory In Vivo
MSI-A Blocks BAL Antigen-Induced Eosinophilia In Vivo
Asp/vehicle
Asp/A
Asp/Dex
naive
Mean Cell Number (+ SEM)
1,250,000
1,000,000
750,000
500,000
250,000
0
Macrophages
Eosinophil
Neutrophils
Lymphocytes

Figure 16

Effect of Compound A on Ig Production

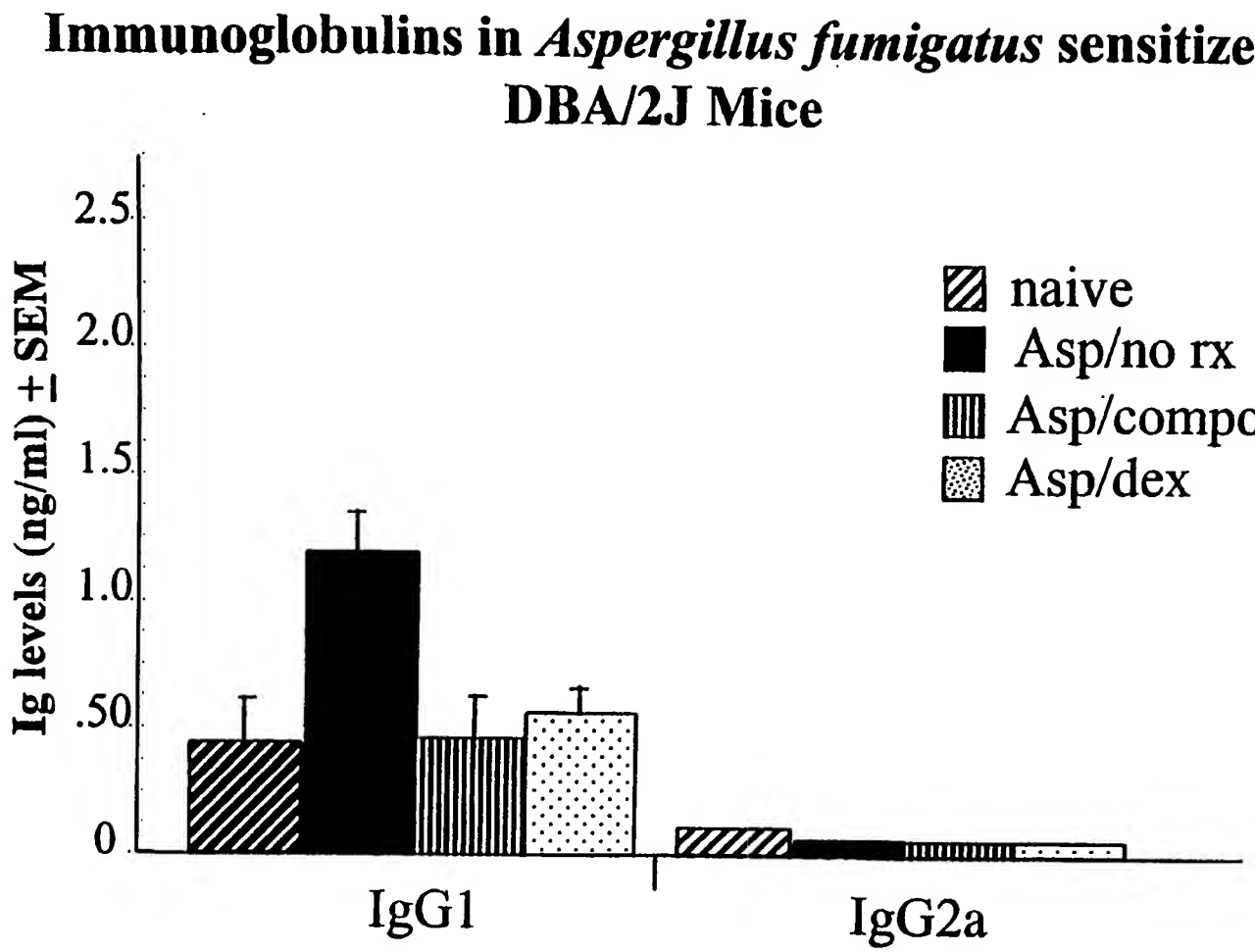


Figure 17

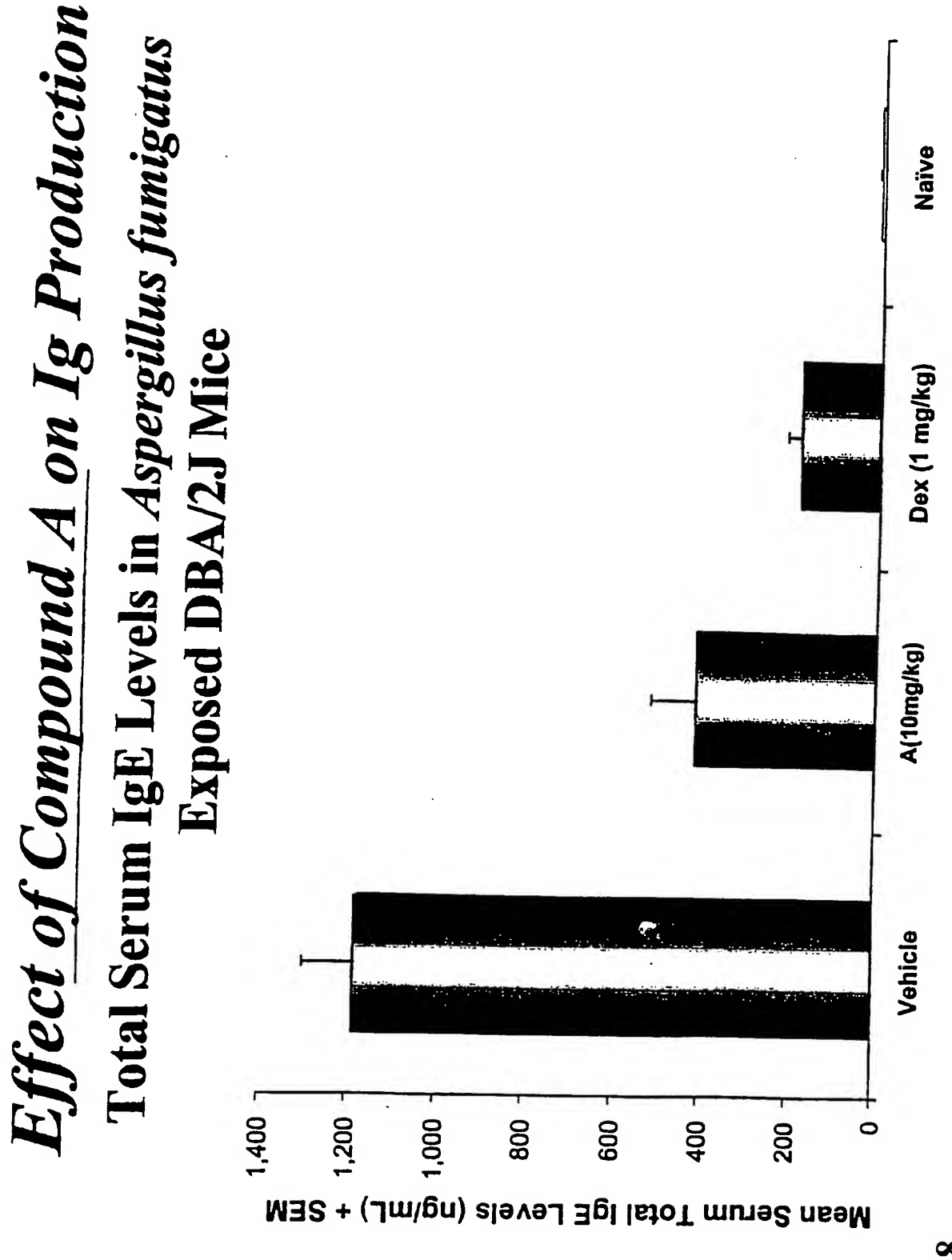

Effect of Compound A on Ig Production
Total Serum IgE Levels in Aspergillus fumigatus Exposed DBA/2J Mice
Mean Serum Total IgE Levels (ng/mL) + SEM
0
200
400
600
800
1,000
1,200
1,400
Vehicle
A(10mg/kg)
Dex (1 mg/kg)
Naïve

Figure 18

Effect of Compound A Aminosteroid on Airway Hyperreponsiveness in *Aspergillus fumigatus*-sensitized BALB/c Mice

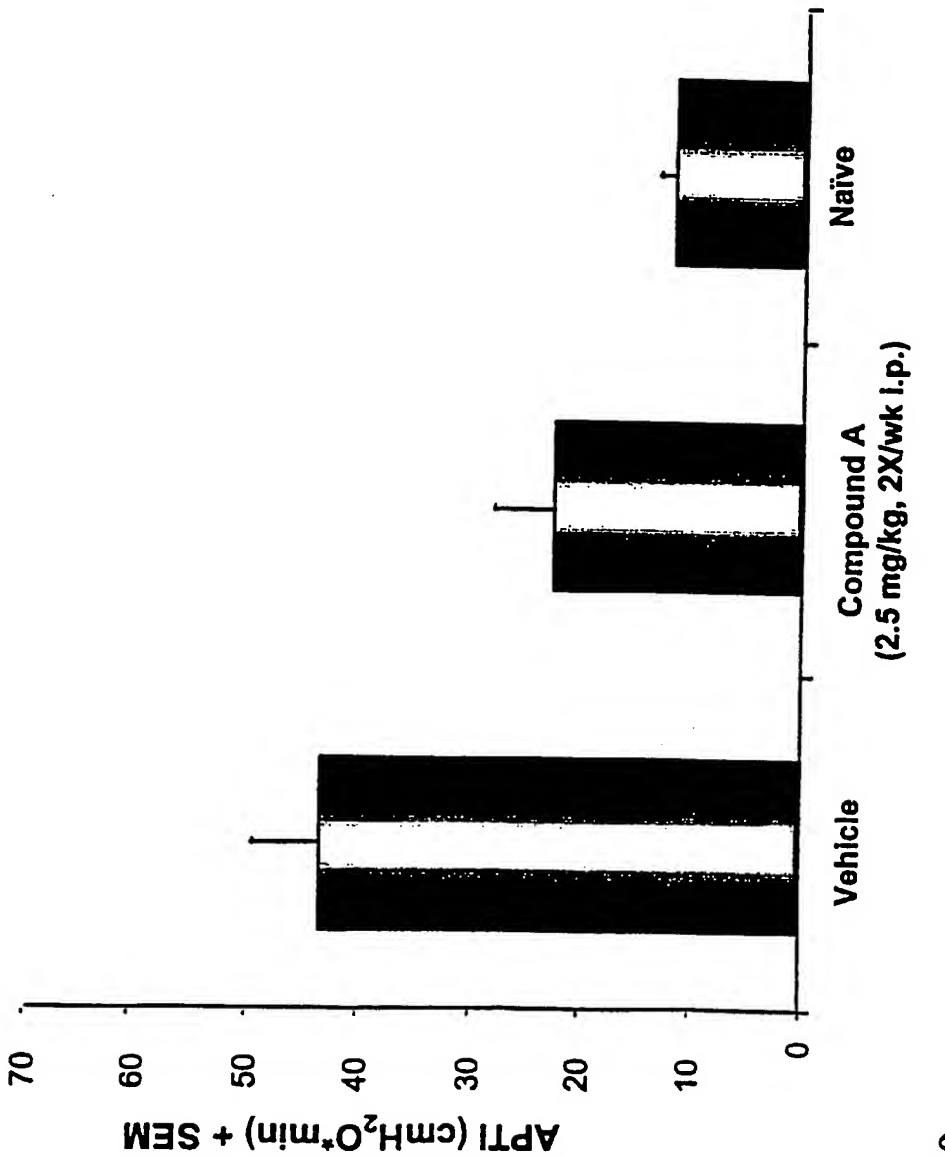


Figure 19

Aminosteroid Toxicology

Effect of Compound B or Dexamethasone on Rat Corticosterone

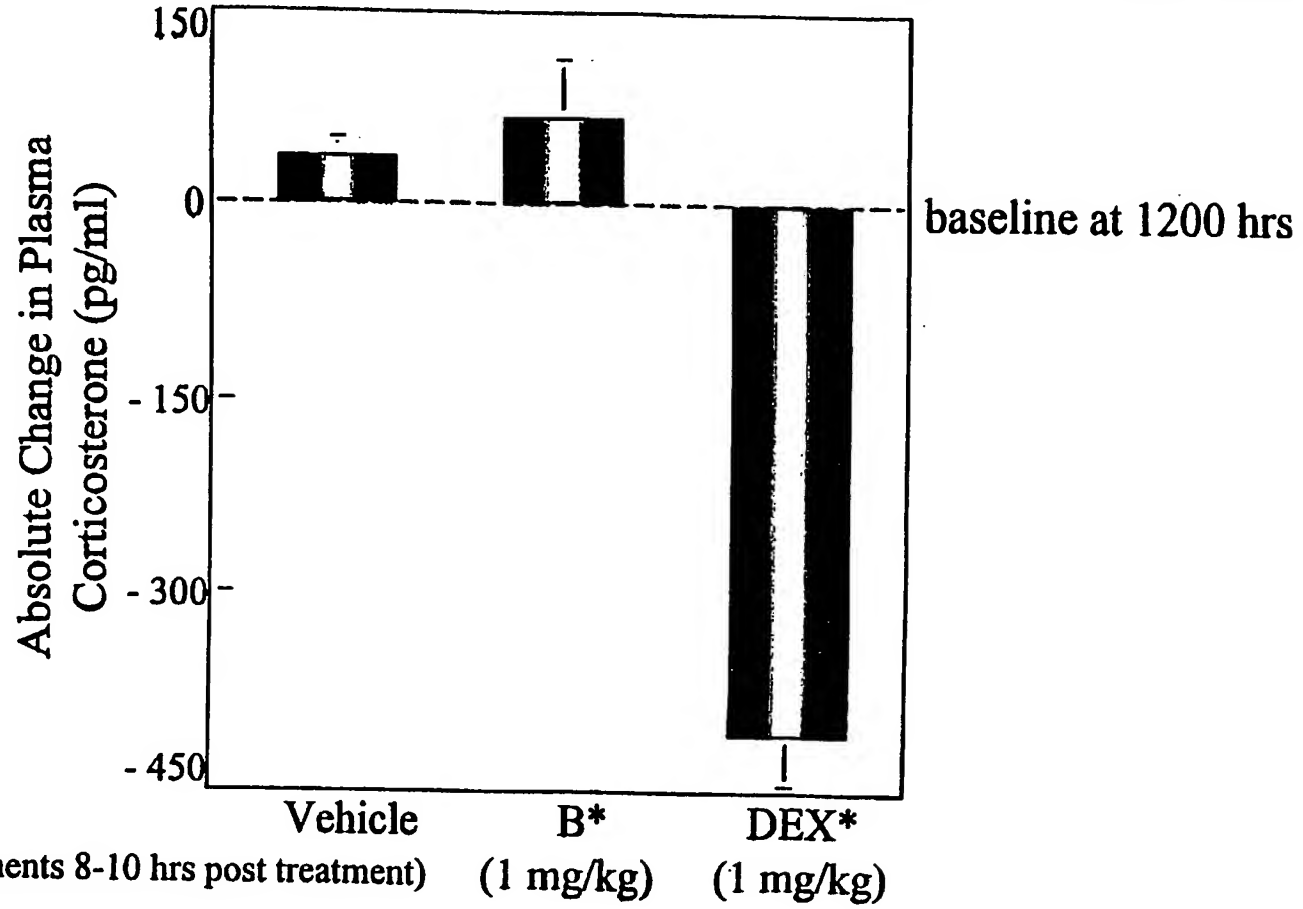


Figure 20

Aminosteroid Toxicology

Effect of Compound B or Dexamethasone on Spleen Weight of Rats

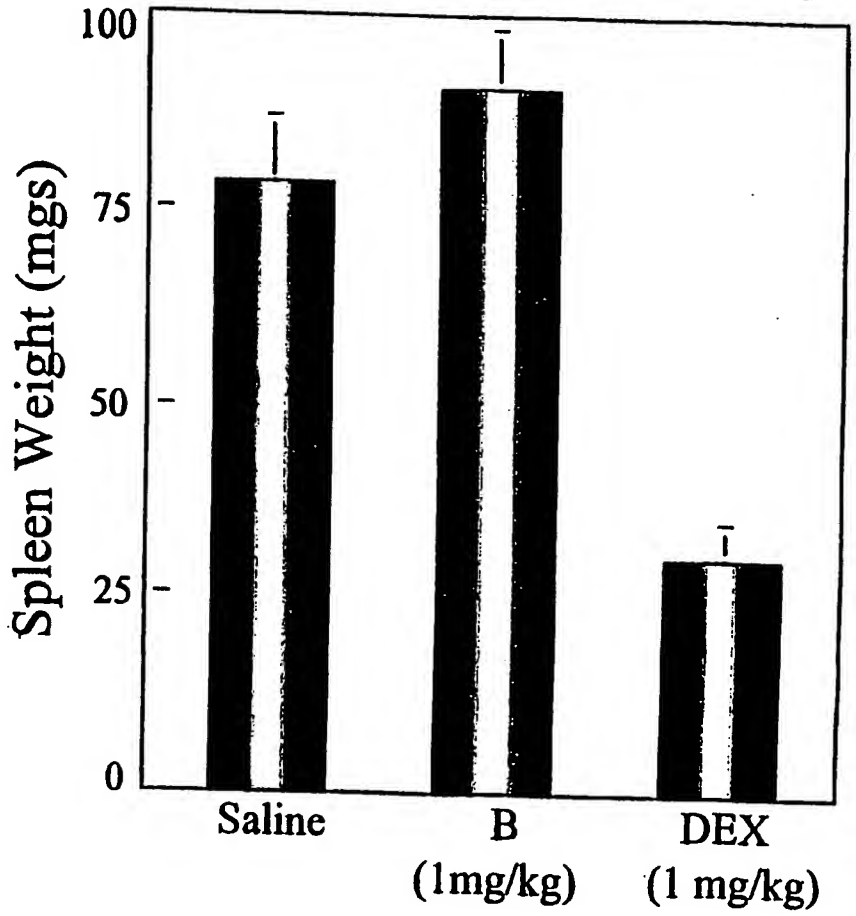


Figure 21

Aminosteroid Toxicology

Effect of Compounds A, B or Dexamethasone on Spleen Weight of Mice

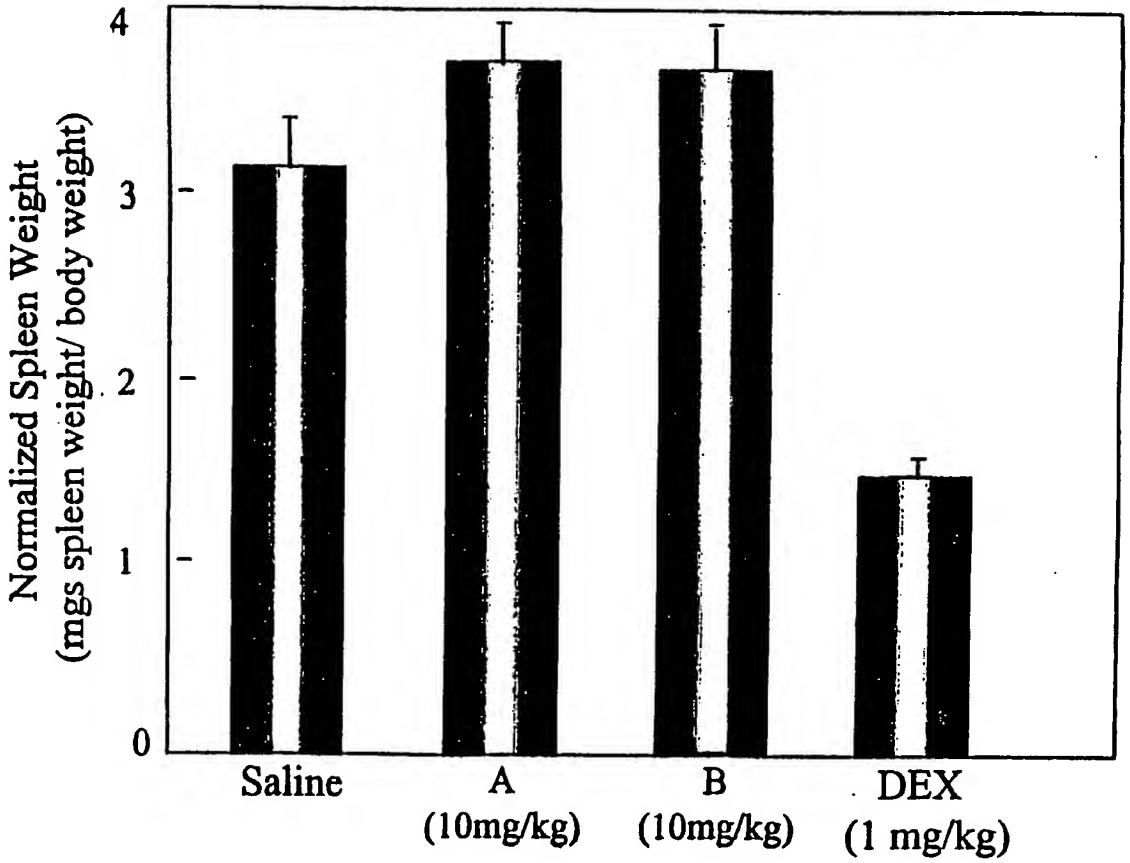


Figure 22

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 June 2001 (14.06.2001)

PCT

(10) International Publication Number
WO 01/42273 A3

(51) International Patent Classification[7]: C07J 41/00, A61K 31/56, G01N 33/48, 33/50

(21) International Application Number: PCT/US00/33526

(22) International Filing Date:
11 December 2000 (11.12.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/169,959 9 December 1999 (09.12.1999) US

(71) Applicant *(for all designated States except US)*: **GENAERA CORPORATION** [US/US]; 5110 Campus Drive, Plymouth Meeting, PA 19462 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **LEVITT, Roy, C.** [US/US]; 5110 Campus Drive, Plymouth Meeting, PA 19462 (US). **NICOLAIDES, Nicholas** [US/US]; 5110 Campus Drive, Plymouth Meeting, PA 19462 (US). **KINNEY, William, A.** [US/US]; 5110 Campus Drive, Plymouth Meeting, PA 19462 (US). **JONES, Steve** [US/US]; 5110 Campus Drive, Plymouth Meeting, PA 19462 (US).

(74) Agent: **TUSCAN, Michael, S.**; Morgan, Lewis & Bockius LLP, 1800 M Street, N.W., Washington, DC 20036-5869 (US).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

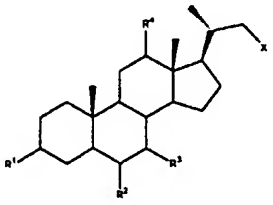
Published:
— *with international search report*

(88) Date of publication of the international search report:
30 May 2002

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 01/42273 A3

(54) Title: ASTHMA ASSOCIATED FACTORS AS TARGETS FOR TREATING ATOPIC ALLERGIES INCLUDING ASTHMA AND RELATED DISORDERS



(I)

(57) Abstract: This invention relates to methods for treating asthma or allergy in a mammal by administering a 3-aminosteroid compound to a mammal in need thereof. The 3-aminosteroid compound being capable of down regulating the IL-9 pathway and alleviating asthmatic responses to allergen. Exemplary 3-aminosteroid compounds used in the methods of the invention include compounds having the chemical formula (I), wherein X, R^1, R^2, R^3, and R^4 groups are as defined herein. The invention also relates to certain novel compound of formula (I). Moreover, the invention also provides methods for identifying an immunomodulatory 3-aminosteroid compound.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/33526

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C07J41/00 A61K31/56 G01N33/48 G01N33/50

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C07J A61K G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, BIOSIS, BEILSTEIN Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 5 908 839 A (LEVITT ROY CLIFFORD ET AL) 1 June 1999 (1999-06-01) column 7, line 59 - line 62; claim 4; figure 19; example 9 ---	1,2 3-8
X Y	US 4 917 826 A (WALLACH DECEASED DONALD P ET AL) 17 April 1990 (1990-04-17) column 2, line 43 - line 60; examples 53,126 column 9, line 33 - line 59 column 3, line 17 - line 21 ---	1,2 3-8
X	WO 99 15656 A (MAGAININ PHARMA) 1 April 1999 (1999-04-01) page 4, line 15-17; claims 12-14; figure 14; example 1 --- -/--	1-8

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 February 2002	11 March 2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Härtinger, S

3

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Interr ›nal Application No
PCT/US 00/33526

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99 44620 A (HOLROYD KENNETH J ;NICOLAIDES NICHOLAS C (US); DONG QU (US); MALOY) 10 September 1999 (1999-09-10) claims 14-16; example 8	1-8
Y	page 30, line 2 - line 8	1-8
Y	claim 28	9-16
Y	US 5 840 740 A (RAO MEENA ET AL) 24 November 1998 (1998-11-24) examples 380,394-396,355-356,409-411,431-432,448,458-466	1-8
Y	column 75 -column 76	9-16
Y	US 5 847 172 A (SHINNAR ANN ET AL) 8 December 1998 (1998-12-08) claims 1-10	1-8
A	US 4 778 750 A (GOTTLIEB A ARTHUR) 18 October 1988 (1988-10-18) claims 1,6,14	9-16
A	US 5 985 665 A (BUCCI LUKE ET AL) 16 November 1999 (1999-11-16) column 3, line 18 - line 57	9-16
A	WO 91 18626 A (US GOVERNMENT) 12 December 1991 (1991-12-12) page 19; claims	9-16
Y	"interleukin-9" 'Online! 14 April 1999 (1999-04-14) , COPE CYTOKINES ONLINE PATHFINDER ENCYCLOPAEDIA XP002190626 Retrieved from the Internet: <URL: http://www.copewithcytokines.de/cope.cgi?3266> 'retrieved on 2002-02-18! *http://www.copewithcytokines.de/cope.cgi?000753*	9-16

3

INTERNATIONAL SEARCH REPORT

Ir ational application No.
PCT/US 00/33526

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

Although claims 1-8 are directed to a method of treatment of the human or animal body, the search has been carried out and based on the alleged effects of the 3-aminosteroid compound.

2. [ ] Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this International application, as follows:

see additional sheet

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [X] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

1-16

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[X] No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-8

   method of treating atopic allergy and asthma

2. Claims: 9-16

   methods of identifying an immunomodulatory 3-aminosteroid

3. Claims: 17-20

   a 3-aminosteroid compound

INTERNATIONAL SEARCH REPORT

...formation on patent family members

Inter onal Application No
PCT/US 00/33526

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5908839 A	01-06-1999	AU 6895696 A	19-03-1997
		CA 2230240 A1	06-03-1997
		EP 0846173 A1	10-06-1998
		JP 11514851 T	21-12-1999
		WO 9708321 A1	06-03-1997
		US 6261559 B1	17-07-2001
		US 6037149 A	14-03-2000
		ZA 9607182 A	25-05-1998
US 4917826 A	17-04-1990	EP 0243449 A1	04-11-1987
		JP 63501217 T	12-05-1988
		WO 8702367 A2	23-04-1987
		US 5373095 A	13-12-1994
		US 5621123 A	15-04-1997
		US 5196542 A	23-03-1993
		US 5145874 A	08-09-1992
		US 5187299 A	16-02-1993
		US 5274089 A	28-12-1993
		US 5334712 A	02-08-1994
WO 9915656 A	01-04-1999	AU 9490698 A	12-04-1999
		EP 1025223 A2	09-08-2000
		JP 2001517682 T	09-10-2001
		WO 9915656 A2	01-04-1999
WO 9944620 A	10-09-1999	AU 2981999 A	20-09-1999
		EP 1067940 A1	17-01-2001
		WO 9944620 A1	10-09-1999
US 5840740 A	24-11-1998	AU 723663 B2	31-08-2000
		AU 6334996 A	30-12-1996
		CA 2223910 A1	19-12-1996
		EP 0832094 A2	01-04-1998
		WO 9640728 A2	19-12-1996
		US 5856535 A	05-01-1999
US 5847172 A	08-12-1998	AU 723663 B2	31-08-2000
		AU 6334996 A	30-12-1996
		CA 2223910 A1	19-12-1996
		EP 0832094 A2	01-04-1998
		WO 9640728 A2	19-12-1996
		US 6143738 A	07-11-2000
US 4778750 A	18-10-1988	AT 83324 T	15-12-1992
		DE 3782958 D1	21-01-1993
		EP 0238851 A2	30-09-1987
US 5985665 A	16-11-1999	AU 720703 B2	08-06-2000
		AU 3393497 A	07-01-1998
		CA 2258803 A1	24-12-1997
		EP 0925370 A1	30-06-1999
		IL 127576 A	06-12-2000
		JP 2000514287 T	31-10-2000
		WO 9748821 A1	24-12-1997
		ZA 9705359 A	18-12-1998
WO 9118626 A	12-12-1991	US 5344755 A	06-09-1994
		AU 654668 B2	17-11-1994

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte onal Application No
PCT/US 00/33526

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9118626 A		AU 8186591 A	31-12-1991
		CA 2084883 A1	09-12-1991
		EP 0593471 A1	27-04-1994
		JP 2969197 B2	02-11-1999
		WO 9118626 A1	12-12-1991
		US 5514556 A	07-05-1996